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HYDRAULIA.

On Stone by Fussell

SIR HUGH MYDDELTON. BAR^T

THE PROJECTOR OF THE NEW RIVER AQUEDUCT

London Pub^d by Simpkin, Marshall & C^o March 23 1833

HYDRAULIA;

AN HISTORICAL AND DESCRIPTIVE ACCOUNT

OF

THE WATER WORKS OF LONDON,

AND

THE CONTRIVANCES FOR SUPPLYING OTHER GREAT CITIES,

IN DIFFERENT AGES AND COUNTRIES.

BY WILLIAM MATTHEWS,

Author of "The History of Gas Lighting," &c.

LONDON:

SIMPKIN, MARSHALL, AND CO., STATIONERS' HALL COURT.

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PREFACE.

Water is so essential both to the animal and vegetable creation, either for aliment or other purposes, that its importance probably surpasses every other substance amongst the great exuberance bestowed by the beneficent Author of Nature. The health, comfort, and enjoyment of mankind constantly require a plentiful supply, and therefore, if utility be a just criterion of value, the inventions and operations to furnish it readily and abundantly, in a clear and salubrious state, would seem to be entitled to peculiar attention.

Signally important and extensively beneficial to the community, as are the great establishments for supplying water, correct information concerning them is strikingly limited. For although numerous and capacious conduits beneath the surface of our streets, with their ramifications, convey water to the loftiest residences, adequate to all the wants and emergencies of populous cities, yet comparatively few persons have a slight degree of knowledge of the ingenious means employed to afford such advantages. Hence, no work having heretofore appeared in our language, peculiarly devoted to describing the principal contrivances devised in different ages, and various countries, for effecting these purposes, it is the aim of the following publication to supply the defect, by an assemblage of facts, displaying the multifarious efforts to apply the resources of science, and the powers of art, to realize an object of the highest utility to society.

The institutions of this nature, at present existing in Great Britain, have probably occasioned the expenditure of twenty millions of money; and during the last five

years in almost every session of Parliament, applications have been made from different places for Acts, either to authorize the construction of new works, or the improvement of others previously constructed. This subject did not elude the consideration of the sagacious Dr. Benjamin Franklin, who constantly aimed at rendering his talents and attainments subservient to the welfare of humanity. Hence, among the different laudable objects enumerated in his will, for employing a portion of that property, which he bequeathed to accumulate, with a view to its subsequent expenditure for effecting several great public benefits, the construction of *water-works* to supply the City of Philadelphia was particularly specified.

London, Edinburgh, and various other places in this country, have long possessed some rather peculiar advantages in the practice of supplying water to their residents; but singular as the fact may appear, similar efficient plans have not hitherto been introduced to supply common wants, or extraordinary exigences, in the principal cities on the continent of Europe. At an era distinguished for promptitude in adopting improvements, such a circumstance may excite surprise, because even at a late period, taste and genius have been exercised in contriving superb fountains, and constructing other works to effect the same purpose. This remark particularly applies to Paris; but from the science, labour, and expense recently bestowed upon a very comprehensive project, it is probable that in the course of a few years, its residents will be amply and skilfully supplied.

Pre-eminent as our nation may be for magnificent and useful enterprizes, as well as for contrivances conducing to domestic and social convenience, nevertheless the paucity of our structures, for the salutary and pleasurable exercise of bathing, is remarkable. The devices of other nations and ages for this purpose, exhibit much varied ingenuity:—those of ancient Rome and Alhambra in Spain, excite wonder and admiration; but in modern

times, the public and private baths abounding in France, Italy, Turkey, Hungary, Russia, and Egypt, should rouse us to emulation.

The materials for this attempt have been both sedulously and carefully collected from authentic sources; and in describing machinery the use of technical terms has been avoided, as far as possible, in order to render it interesting to every class of readers. From the magnitude and importance of the Water Works of London, they necessarily occupy a considerable portion of the work; but in recounting the schemes proposed at various periods, such only have been selected as seemed to be deserving of notice, either for their novelty or utility.

Efforts were made, in 1827, to alarm the inhabitants of the metropolis about the condition of the Thames, which was stated to be so deleterious as to prove fatal to the fish, and consequently its use became dangerous for domestic purposes. That such a representation did not emanate either from accurate knowledge of the real qualities of the water, or a laudable desire to benefit the public, will be palpably evident to every person, who may attentively and dispassionately peruse the testimony adduced to render the story plausible. In the subsequent pages the delusive and erroneous statements broached on that occasion, have, therefore, been scrutinized with a rigid regard to truth and probity; but since that part of the work was printed, another attempt has been made to produce similar impressions, in order to recommend a scheme "for supplying the metropolis with *pure spring water.*" To promote the views of the projectors they have appended to their prospectus many of the preposterous, contradictory, and incredible *statements* of persons strikingly *ignorant* of the nature and properties of *coal gas*, to which the evils were chiefly ascribed; adding also the unauthorized *opinions* of some *medical* practitioners, who rendered themselves conspicuous in improperly exciting apprehensions. Although the latter

were pompously designated—"*eminent*," and "*men of very high eminence*," &c. yet in regard to the subject of their vituperation, their confident asseverations displayed a lamentable deficiency of judgment, discrimination, and scientific information. This farrago of absurdities may obtain attention, and guide the decisions of such as mistake bold assertions for positive truths, and believe without the trouble of inquiry; but those who possess only a moderate portion of *geological* and *chemical* knowledge, will probably smile at this ludicrous endeavour to impose upon their understandings. According to their own account, the *spring-water* philosophers have bored "orifices of *five inches* in diameter," and because water has risen to the surface, they conclude that a proportionately large quantity will inevitably arise and fill "one orifice about *six feet* in diameter, and afford a supply *equal to the whole quantity* supplied by *all* the Water Companies of the metropolis, on *both sides* of the Thames"!!! Hence without any change in the constitution of nature, or the strata of the earth, in London and its vicinity, these sagacious logicians infer, that sources which, in former ages, were barely adequate to form a rivulet, are now become so prolific, as to yield water almost sufficient to fill the channel of a great river! Can any fallacy be more glaringly obvious? Besides, analyses have proved that, the water furnished by some of these springs, actually contains considerably more extraneous matter, than any taken from the much-decried Thames, which innumerable mariners have constantly used as their beverage, without a single instance of complaint by them of its being "*poisonous*," or even slightly affecting their health!

The proceedings of different Select Committees of the House of Commons, which have been printed by their order, contain facts and details of considerable importance relating to water-works; but unfortunately for the public, the knowledge of them is confined to a very

limited circle. From those authentic documents the author has derived much curious and interesting information, illustrating the endeavours of individuals to realize their own sordid views, by professing to aim at promoting the welfare of the community. This statement is amply corroborated by the evidence given to the Commissioners in 1828, and to the Committee in the same year, as well as to that appointed in 1834, to consider Mr. Telford's Report on the Supply of Water to the Metropolis; for those inquiries occasioned the disclosure of some singular and striking facts, elucidating the motives and qualifications of persons, who were most active and vociferous in decrying the condition of the Thames, obviously for the sole purpose of getting themselves employed in making surveys, and constructing *new water-works* for London, at an enormous expense to the nation! A summary of their transactions has therefore been given, to enable the reader to form his own decision concerning them.

To conclude: if some circumstances in the course of the narration have occasioned reflections that may seem, in any degree, to savour of asperity, the expression of those sentiments proceeded from no disposition to be uncandid or censorious, but an inflexible regard for truth, sincerity, and rectitude, which ought invariably to guide the pen of an historian.

April, 1835.

The Portrait of Sir Hugh Myddelton may be had separately . . . . . . price 1*s*. 0*d*.
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HYDRAULIA.

WATER WORKS OF LONDON, &c.

CHAPTER I.

The earliest artificial devices to obtain clear Spring Water for common use. Modes of supplying London prior to William the Conqueror, &c. Fitz-Stephen's description of them in the reign of Henry II. Sites of different Fountains. First Lead Cistern at West-cheap. Periods of constructing various Conduits. Hampstead Water-works. Lambe's Conduit. Benefactions for making and repairing Conduits. Annually visited by the Lord Mayor, Aldermen, &c. Situations of the Conduit-heads. Rolle's Reflections upon the Destruction of the Conduits by the great Fire in 1666. Remains of one at Bayswater. Verses placed on some of them when James I. passed through the City at his accession to the English Crown.

If the chief design and end of human life were merely the acquisition of the few objects generally essential for the support of animal existence, the rude savage, who dwells in solitudes, or roams the wilderness, would be equally gratified with the most refined of his species. The natural and spontaneous productions of the earth commonly satisfy his wants. The fruit of the tree and the root of the vegetable appease his hunger; the limpid streamlet slakes his thirst; and as health or pleasure may suggest, he laves his body in the majestic or gently flowing rivers, meandering amongst the romantic, beautiful, and variegated scenes of his wanderings. But different circumstances have prompted a great portion of our species to seek for enjoyments of a superior kind. The social

propensities gradually produced a taste for intellectual cultivation, which modified the estimate of felicity, and with other causes, progressively gave rise to numerous factitious wants, requiring ardent as well as persevering exertions for their gratification. Hence all the rational faculties and physical energies of man became developed and actively employed for subserving his purposes in that career of improvement, which seems to have been his primary destination.

As *good water* is the most simple, common, and necessary aliment of the animal creation, and especially of mankind, the means of procuring it have ever occasioned a proportionate degree of solicitude. The earliest records afford the information, that wherever people had made some advances in civilization, it was their practice to form *wells* or *fountains* at such places as would conveniently furnish a supply for their beverage and other uses. Many contrivances of this kind are mentioned by ancient writers; and modern travellers concur in representing that the same primitive devices still continue; but this is more particularly the case in those countries where even a scanty quantity of water is often very important, both to the migratory pastoral tribes, and to the residents of the towns and villages. In the pages of sacred history, the wells of Abraham and Isaac are mentioned, with the contentions which they occasioned.* Maundrell and other travellers have noticed that of David near Bethlehem; and Jacob's is rendered memorable by the conversation of Jesus with the woman of Samaria, to whom, when wearied, he said, "Give me to drink."† Probably the two latter are still subservient to the same purposes that originally led to their construction. Indeed, at the pre-

* Genesis, xxvi. † John, xiv.

sent period, the inhabitants of that celebrated country, as well as those of many other nations, obtain their supply for domestic uses principally by similar means, though other methods have been devised and adopted in several countries of Europe.

The plentiful supplying of salubrious water, to the population of London and its suburbs, has occupied great attention and consideration during many successive centuries. Curiosity may therefore be agreeably interested in learning from what sources it was procured, as well as the means employed, at various eras, to furnish an article so necessary for human subsistence and comfort. Hence a detail of the different schemes proposed and adopted by our progenitors, will not only show the degree of knowledge and skill of the respective projectors, but also serve to exhibit the progress of improvement, in providing the means of affording to the metropolis abundance for every domestic want and convenience.

Prior to the construction of water works at London Bridge, and the New River, the inhabitants obtained their principal supply either from the Thames, or the springs which arose in the elevated grounds situate to the north or west of the City; and it was conveyed from the latter sources by means of earthen or leaden pipes, to different conduits or fountains, erected at various places to receive it. Fitz-Stephens refers to this fact in his *Description of London in Henry the Second's Reign*, when he states that "round the city again, and towards the north arise certain excellent springs at a small distance, whose waters are sweet, salubrious, clear, and

"'Whose runnels murmur o'er the shining stones.'

Among these, Holywell, Clerkenwell, and St. Clement's Well, may be esteemed the principal, as being much the

best frequented, both by scholars from the schools, and youth from the city, when in a summer's evening they are disposed to take an airing."*

In the reign of Queen Elizabeth, John Stow, a very diligent antiquarian, published *A Survey of London*, in which he narrated many circumstances relative to this particular subject. As he was careful in his inquiries, the authenticity of his statements are unquestionable, and the simplicity as well as quaintness of the phraseology, render his recitals both amusing and impressive. He observes that—

"Anciently until the Conqueror's time, and for 200 yeares after, the Citie of London was watered, (beside the famous River of the Thames on the south part,) with the River of *Wels*,† as it was then called; on the west; with water called *Wallbrooke*—running through the midst of the Citie into the River of Thames—serving the heart thereof;—and with a fourth Water or Boorne,‡ which run within the Citie through Langbourne Ward watering that part in the east. In the west was also another great water, called *Oldborne*."

* Pegge's Translation.

† Pennant states that "the river of Wells, or Wal-brook, is mentioned in a charter of William the Conqueror to the College of St. Martin's-le-Grand, and it rose to the north of Moorfields, passed through London Wall between Bishopsgate and Moorgate, and ran through the City for a long time quite exposed, having several bridges erected over it. Two or three centuries ago it was vaulted over with brick, paved at the top, and formed into a street, now called Wallbrook." He also remarks that "formerly barges of considerable burden flowed up the river Fleet as high as Holborn Bridge, over it were four stone bridges, on its sides extensive quays and warehouses, and it was scoured and kept open at a vast expense, nearly 20,000*l.* having been applied to that purpose, in 1606."

‡ A brook.

"Then were there three principal fountaines, or wels in the other suburbs: to wit, *Holywell*, *Clement's Well*, and *Clerke's Well.* Neare unto this last fountaine, were divers other wels; to wit, *Skinner's Well*, *Fag's Well*, *Tode Well*, *Loder's Well*, and *Radwell.* All which said wells having the fall of their overflowing into the aforesaid River much increased the streame, and in that place gave it the name of *well.* In West Smithfield there was a poole in Records, called *Horsepoole;* and another neare to the Parish Church of St. Giles' Cripplegate. Besides which they had in every gate and lane of the Citie divers faire wels, and fresh springs, and after this manner was this Citie then served with sweet fresh waters; which being since decayed, other means have been sought to supply the want, as shall be showed: but first of the aforenamed Rivers and Waters is to be said as followeth:

"The said River of *Wels*, the running Water of Wallbrooke, the *Boornes*, &c. and other fresh waters that were in about the Citie being in process of time, by incroachments for buildings, and heightening of grounds, utterly decayed; and the number of citizens mightily increased, they were forced to seek for waters abroad, whereof some at the request of King Henry the Third, in the twenty-first yeare of his reigne, were for the profit of the Citie, and good of the whole realme, thither repairing to wit, for the poore to drink, and the rich to dress their meate.

"The first Cisterne of lead, castellated with stone in the Citie of London was called the great Conduit in West-cheap, which was begun to be builded, in the yeare 1235, Henry Wales being then mason. The water-course from Paddington to James head hath 510 rods; from James head on the hill to Mewsgate 102 rods; from the Mews-

gate to the Crosse in Cheape 484 rods." * This statement contains the earliest intimation of any attempt being made to supply London with water by means of leaden pipes; and according to the account which has been transmitted of the progress of the work, it was not completed till 1285, so that its execution occupied the long period of fifty years. What a striking instance of the sluggish efforts of our progenitors in important public undertakings!

"The pipes used for the conveyance of water in those times were not in some instances imbedded in the earth, as is the present custom, but inclosed within a capacious arch of brickwork, into which workmen could, upon occasion, descend to repair any decay or accident, which might happen to them. In a report of the Dog House Conduit (*Hist. of Shoreditch*) three several springs of water are said to be '*conveyed in draines of brick to a Conduit house*,' &c.

"In digging for gravel at Islington, lead pipes of a large size have been discovered, branching in various directions, supposed to have been connected with the springs that supplied the Priory in Smithfield, from the place then called the Conduit-head of St. Bartholomew."†

"At the time of digging for the foundation of Highbury House, in 1781, a great collection of pipes, made of red earth baked, resembling those used for the conveyance of water, about the time of Queen Elizabeth, were dug up; and similar discoveries of leaden pipes have been made at different times in the fields between Canonbury and Highbury."‡

Though the execution of the scheme mentioned above, commenced in 1235, the following year another transac-

* Stow. † Nelson's *History of Islington*. ‡ *Ibid.*

tion took place, which displays the great attention bestowed upon the supply of water at that period. It is recorded that some merchants of Amiens, Nele, and Corby, being solicitous to obtain the privilege of landing and housing woad, &c. actually purchased it from the Mayor and citizens, for the consideration of a yearly payment of fifty marks, and the donation of one hundred pounds towards the expense of the operations then going on for conveying water from "*Tyborne*" to the City. This important undertaking originated in a grant from Gilbert de Sandford, enabling the "Lord Mayor and Commonalty to lay down a leaden pipe of six inches bore from six fountains, or wells" in that vicinity; and as this useful work was expensive, the principal citizens were liberal in their contributions. The particular parts of the City to which this large pipe extended, are not mentioned, so that it probably did not reach further than the western boundary; for it is stated that "in 1432, Tyborne water was laid into the Standard Cheapside, at the expence of Sir John Wells, Lord Mayor; and likewise in 1438, by another Lord Mayor, Sir William Eastfield, from Tyborne to Fleet-street and Aldermanbury; and from Higbery to Criplegate."*

"The conduit formed at Highbury by Sir William Eastfield was opposite Highbury-place, but is now arched over with brick—its situation being marked by an upright stone which points out the direction of the springs on the higher ground, from which it receives its supply. From this ancient conduit which remained open as a watering-place for cattle before the building of Highbury-place, many of the houses there are now served with water, a proper communication having been made on building

* Stow.

them for that purpose. By these means it flows into wells, or reservoirs behind the houses, which also communicate with each other, the lower well receiving the surplus water when the upper one is filled."*.

Some other circumstances which occurred at an early period relative to this subject, are both important and interesting. "From the River of Thames did the citizens, in former times, supply themselves with water for family uses; fetching it by many lanes that led to the water side in divers wards of the citie. But in time many of these lanes were stopt up by those that dwelt thereabouts, for their own gain, who would suffer none to pass without paying a duty This became a great grievance, insomuch that in 17 Edw. III. (1342) the Maior, Aldermen and Commonalty, received great complaints of stopping up these lanes and passages to the Thames. Upon this an inquisition was made, and divers persons of the several wards sworn to make diligent enquiry into these grievances, and of all the lanes that were common passages to the Thames, who brought in presentments of them, and of the annoyances and stoppages of them in several wards." †

The solicitude with which the same object was pursued will be evident from the following statement. In 1439, "the Abbot of Westminster granted to Robert Large, the Lord Mayor, and the citizens of London, and their successors, one head of water containing twenty-six perches in length and one in breadth, together with all the springs in the manor of Paddington, in consideration of the City paying for ever to the said Abbot and his successors, on the Feast of St. Peter, two pepper-corns. But if the intended work should draw the water from the ancient wells, in the manor of Hida, then the grant to cease, and

* Nelson's *Hist. of Islington.* † Stow.

become entirely void. This grant was confirmed by Henry VI., and likewise a writ of Privy Seal issued allowing the Lord Mayor and citizens power to purchase 200 fodder (loads or tuns) of lead for the intended pipes, or conduits; and also to impress plumbers, labourers, &c. for carrying on the said work, provided always that their wages be punctually paid thereon." The same Mayor, in that year, "gave to the new conduits then in hand forty markes; and towards the vaulting over Walbrooke, neere to the parish church of St. Margaret's, in Lothbury two hundred markes." *

The execution of these useful works seems to have occupied several successive years; for "William Combes, sheriffe, 1441, gave to the works of the conduits 10*l.*;" and in the year 1442, "a new crosse was built in West-cheape, for the honour of the citie. The conduit in Westcheape was built in that year, and that in Alder-manbury in 1471, as well as the standard in Fleet-street. In 1476, Richard Rawson, one of the sheriffes, gave towards the worke of the conduits, 20*l.*; and in 1478, a cistern was added to the standard in Fleet-street, another at Fleet-bridge, and another without Criplegate. The conduit in Gras Street was built jn 1491; and Oldborne Cross about 1498."†

By a report made to the Lord Mayor, Aldermen, and Common Council, in December 1692, it appears that the springs near Islington consisted of two heads; one covered with stone, in a field near to Jack Straw's Castle, and fed by sundry springs in an adjoining field. It was usually denominated *The White Conduit*, and from it the water was conveyed by a leaden pipe to the other conduit in Chambery field, where the produce of both

* Stow. † Ibid.

being united, flowed thence to the conduit at Cripplegate.

Notwithstanding the construction of so many conduits, the supply of water was so scanty, that the inhabitants of the city experienced difficulties in supplying their wants, and required some additional means of furnishing it. Other conduits were therefore constructed "by Stocke's Market, and at London Wall, in 1500; at Bishopsgate in 1513; and at Eoldgate, against Coleman-street, in 1528."* In 1535, the Common Council granted a sum of money for the purpose of conveying water from Hackney to a conduit erected at Aldgate, with the view of affording a more ample supply to the eastern part of the city.

The source, according to the report mentioned above, consisted of two heads, walled and inclosed, situated in two fields near Dalston, whence it was conveyed by two leaden pipes which were laid in the earth, varying in their depth below the surface from eight to eighteen feet, till they terminated at the conduit, Aldgate.

The quantity of water furnished from all the sources heretofore enumerated still proving inadequate to the wants of the citizens, the deficiency occasioned the corporation to apply to Parliament in 1544, for an act to enable them to convey water to London from Hampstead Heath, Marylebone, Hackney, and Muswell Hill. Hence authority was obtained for rendering the springs among the hills of Hampstead and its vicinity, subservient to supply the north-western portion of the metropolis. The following extracts from the act will show its object, as well as the feelings which then prompted the citizens to procure it.

"The Citie of London hath been before this time well

* Stow.

furnished, and abundantly served till of late, that either for the faintness of the springs, or for the driness of the earth, the accustomed course of the waters coming from the old springs and ancient heads are sore decayed, diminished, and abated; and daily more and more be like to appeire and fail, to the great discommodity and displesúre both of the citizens and inhabitants within the said citie and suburbes thereof, as to all other persons having recourse to the same, to the great decay of the same citie, if spedy remedy the sooner be not therein had, foreseen, and provided. For remedy whereof, Sir William Bowyer, Knight,* now Mayor of the said citie, intending and pondering the same necessity, much willing to help and relieve the said citie and suburbes with new fountains and fresh springs, for the commodity of the King's said subjects, calling unto him as well divers grave and expert persons of his brethren, and other of the commonalty of the said citie, as in and about the conveyance of water well experimented, hath, not only by diligent search and exploration, found out divers great and plentiful springs at Hamsted Heath, Marybone, Hackney, Muswell Hill, and divers places within five miles of the said citie, very meet, proper, and convenient to be brought and conveyed to the same; but also hath laboured, studied, and devised the conveyance thereof, by conduits, vaults, and pipes, to the said city, and otherwise to his great travail, labour, and pain; and also to the great charges and cost of the citizens of the said city: which good and profitable purpose cannot sort to conclusion, nor take good effect, without the aid and consent of the King's Majesty, and his high court of parliament."

* This person died in 1544, and was buried in St. Peter's Church, Cornhill.

By this act the Mayor and commonalty of the City of London were authorized "to enter into the grounds and possessions of the King, as well as every other person and persons, bodies politic and corporate, where they shall find or know any such springs to be, or may be found for the intent aforesaid (so that it be not unto their houses, gardens, orchards, or places inclosed with stone, brick, or mud walls), and there to dig pits, trenches, and ditches, to erect heads, lay pipes, and make vaults, and do all and every such things in the same places and grounds which shall be meet, propise, and necessary, only for the conveyance of the said water and springs to the citie, and the suburbes of the same; and also to have free ingress, egress, and regress, in and to all such places where such heads, pipes, or vaults shall be erected, laid, or made, to view and see, from time to time, the said heads, pipes, suspirats, and vaults, and them to amend, repair, translate, and do all things necessary and convenient, as well for the finding of new springs, as for the conveyance of any water or springs new found, or hereafter to be found to the citie and suburbes aforesaid, without interruption, let, or impediment, of the owners of the ground, their lessees, assigns, or ministers, or any other person."

Ample as was the power given to the corporation by the act, nevertheless, it stipulated that adequate compensation should be made to all owners or occupiers of land, within the space of one month after taking possession of it for the works, as well as the value of it estimated by three or four indifferent persons, appointed by a commission from the Lord Chancellor. It also contained a provision that the Lord Mayor and commonalty, and their successors, should "ever yield, bear, and pay to the Bishop of Westminster, for the time being, and to his successors, at the feast of St. Michael the Archangel, one

pound of pepper, in and for acknowledging him and them for the lords and very owners of the said heath." Besides they were strictly prohibited "not at any time hereafter to meddle with the spring at the foot of the hill of the said heath, called Hamsted Heath, now closed with brick, for the ease, commodity, and necessary use of the inhabitants of the town of Hamsted, nor do cause, or procure to be done, any thing, acts, or act, to the impairing, hurt, or diminishing, of the water of the same spring at any time hereafter."

Notwithstanding the apprehensions detailed in the preamble to the act, nearly fifty years were allowed to elapse before its object was realized, for it appears that Sir John Hart, whilst serving the office of Lord Mayor, in 1589—1590, attended to the execution of the works. Upon the declivity between the summit of Hampstead Heath and Pond-street, four reservoirs were formed; and to these, in 1777, another was added in the Vale of Health: the whole five have a communication with each other, and occupy about twelve acres. At about a mile distant from the above, between Hampstead and Highgate, are eight other reservoirs, which have likewise been constructed on different sites of the declivity, between Caen, or Ken Wood, and Kentish Town. The space occupied by these is about twenty acres; and every one in the range has not only a different elevation, but a connection with that immediately above or below it. Formerly two mains, of seven inches bore, were employed to supply the neighbourhood of St. Giles from these reservoirs.

Though the property and management of the Hampstead works originally belonged to the corporation of London, yet at a subsequent period it was deemed eligible to convey their privilege of obtaining and supplying water from that source to several persons, who, in 1692, were

incorporated by the denomination of *The Hampstead Water Company*. Their supply at present extends to about 2,500 houses, situate in the Hampstead Road, Kentish Town, and Camden Town; each house daily receiving on an average about 150 gallons. It may not be irrelevant to state, that by a clause of an Act of Parliament, passed in 1694, for the relief of the Orphans and other Creditors of the City of London, "all the rents and profits arising by any aqueducts, and right of bringing and conveying water, which do, or shall belong to the Mayor, commonalty, and citizens, are to be appropriated and applied towards the payment of the said interest money."

In 1833 a very important improvement was effected in these works, by the making of a well at the bottom of Hampstead Heath. It is seven feet in diameter; and its depth, to the main spring, about 330 feet. As the water from this source is very soft and pure, as well as abundant, averaging more than 200,000 gallons per day, it is another object of the company to erect a steam engine, to elevate a quantity sufficiently high for supplying the town of Hampstead, where the want of a regular supply has long been experienced, particularly in dry seasons.

Various other facts indicate the anxiety of the corporation, as well as private individuals, to benefit their fellow citizens. In 1546, the Common Council voted a sum of money to defray the expense of erecting a conduit at Lothbury, and for the necessary means of conveying water to supply it from Hoxton Fields. During the same year another was also constructed in Coleman Street, near to the church. The scheme of Mr. William Lambe entitles him to particular notice: and he is stated to have been a gentleman belonging to the Chapel Royal of Henry VIII. *Lambe's Conduit* derived its designation

Lamb's Conduit as Rebuilt in 1667
from a Design by Sir Christopher Wren.

from him; for at that place, by his contrivance, several springs were so connected as to form a head of water, which was conveyed by a leaden pipe, about 2,000 yards in length, to Snow Hill, where he rebuilt a conduit which had long been in a ruinous state and disused. It is recorded that he expended altogether upon these structures, a very large sum of money; and his benevolent and zealous efforts, in this instance, conferred an important advantage on a populous neighbourhood. He was a person of a remarkably charitable disposition, and his benefactions for other purposes were also numerous: he was buried in St. Faith's Church, and the following is the conclusion of his punning epitaph:

"O Lambe of God
which since didst take away,
And (as a Lambe)
was offered up for sinne;
Where I (poor Lambe)
went from thy Flocke astray
Yet thou (good Lord)
vouchsafe thy Lambe to winne
Home to thy fold
and hold thy Lambe therein!
That at the day, when
Lambes and Goats shall sever
Of thy choice Lambes
Lambe may be one for ever."

Though the number of conduits had been frequently increased to convey the water from different springs in the vicinity of London, yet the quantity supplied was insufficient to satisfy the demands of the inhabitants. Hence to remedy the defect it became necessary to have recourse to the Thames, and in 1568, a conduit was constructed at Dowgate, for the purpose of deriving assistance from the river. In 1583, conduits for Thames

water were also built by the church of St. Mary Magdalene, and St. Nicholas Cold Abbey, near to Fish Street Hill. Besides, in 1610, Mr. Thomas Hayes, an English gentleman, formed another without the gate at Aldersgate, where the water was conveyed in pipes of wood and stone. These facts demonstrate that although "the stopping up of the lanes and passages to the Thames," had formerly interposed obstacles which prevented many of the citizens from obtaining water for their several purposes, yet necessity impelled a return to the same copious source of supply, as well as gave rise to contrivances for effecting the object.

The projectors of the different conduits, and the persons who enabled them to realize their schemes by pecuniary aid, certainly conferred a signal benefit upon the community at that era. The names of some whose benevolence induced them to promote, by their donations or bequests, the accomplishment of such useful undertakings have been mentioned; but Stow has enumerated several others; two of whom gave 100*l.* each, and one the sum of 900*l.* The various benefactions show that such public conveniences were held in very high estimation, and doubtless their great and obvious utility occasioned them to be so frequently the objects of charitable bounty by wealthy individuals.

According to Stow, the conduits were annually inspected, by the city authorities, with great formality and parade. Indeed these visits seem to have been a kind of festival; for he states that "These conduits used to be, in former times, yearly visited; but particularly on the 18th of September, 1562, the Lord Maior (Harper), Aldermen, and many worshipful persons, and divers of the Masters and Wardens of the twelve Companies rid to the Conduit's head, for to see them after the old

custom. And afore dinner they hunted the hare and killed her, and thence to dinner at the head of the conduit. There was a good number entertained with good cheer by the chamberlain; and after dinner they went to hunting the fox. There was great cry for a mile, and at length the hounds killed him at the end of St. Giles's. Great hallowing at his death, and blowing of hornes: and thence the Lord Maior, with all his company, rode through London to his place in Lombard Street."*

Several facts concerning the conduits are related by an editor of Stow's *Survey of London*, which was re-published, with various additions, in 1633. As some of the statements refer to the causes of their being removed, they will not be deemed irrelevant, and may gratify curiosity; besides, the work appeared twenty years after the completion of the New River, which has proved so advantageous to the metropolis.

"Of the fore-mentioned conduits of fresh water that serve the city, the greater part of them do still continue where first erected; but some, by reason of the great quantity of ground they took up, standing in the midst of the principal and high streets of the city, were a great hindrance, not only to foot passengers, but to porters, coaches, and cars, and therefore thought fit to be taken down, and to be removed to places more convenient, and not of that resort of people, so that the water is still the same.

"The conduits taken away and removed with their cisterns are, the great conduit, at the east end of Cheapside; the great conduit, called the Great Tun, in Cornhill; the Standard, in Cheapside; the little conduit at

* Stow.

the west end of Cheapside; the conduit in Fleet Street; the great conduit in Gracechurch Street; the small conduit in Stocke's Market; the conduit at Dowgate.

"The rest of the conduits before-mentioned are still remaining; so that, what with the spring water coming from the several spring-heads through the streets of the city to these cisterns, the *New River* water from Chadwell and Amwell, and the Thames water, raised by several engines or water houses, there is not a street in London but one or other of these waters runs through it in pipes conveyed under ground; and from these pipes, there is scarce a house whose rent is 15*l.* or 20*l.* a year, but hath the convenience of water brought into it by small leaden pipes, laid into the great ones. And for the smaller tenements, such as are in courts and alleys, there is generally a cock or pump, common to the inhabitants; so that I may boldly say, there is never a city in the world so well served with water."

The means of obtaining water from the conduits consisted either in employing people who made a business of selling it, or sending servants to fetch it, and both plans had their attendant inconveniences. For the purpose of conveying it, they used vessels that were made wider at the bottom than the top, having hoops like a pail, also an iron handle at the upper end, in form like that of a common pewter pot, and fitted with a cork or bung. Each contained about three gallons, so that their weight might be easily carried by a man or woman, either on the head or shoulders. They were called *tankards*, and resembled the vessels at present employed by the dealers in milk, when they convey it home in their carts.*

The respective sources whence the water flowed to the

* Nelson.

different conduits, are enumerated by Maitland, who has likewise interwoven with his description, some other curious and interesting circumstances. Amongst these, the enjoyments of the civic authorities, and their female associates, on the occasion of visiting the conduits, not only depict the rustic simplicity characterizing the amusements, but also convey a vivid impression of the manners, customs, and habits of former times. The display of magisterial agility and horsemanship on the prancing steeds, "in *hunting the hare*," and "the *ladies*" of the Lord Mayor and Aldermen riding in *waggons*, to view the City conduits, present a striking contrast to the dull solemnity, sluggish movements, and gorgeous exhibitions of later days. How degrading and ludicrous would such practices be deemed by the Citizens and their spouses of the present period! Hunting the hare and the fox, hallooing tally-ho, would not comport with the notions now entertained of civic dignity and decorum, and possibly might be looked upon as the "fantastic tricks" and low pleasures of vulgar jollity, though highly esteemed among the gratifications attendant upon some holidays of their unrefined, and perhaps unlettered forefathers.

"The principal places, or conduit heads, from which the water flowed to the conduits, were *Conduit Head*, which now forms the site of Conduit Street, New Bond Street, and several of the adjoining streets;—Tyburn, Paddington, White Conduit Fields, Highbury Barn, and Hackney. The place where the hunting party dined, on the occasion of visiting the conduits, was the Lord Mayor's Banqueting House, then situated on a part of the site at present occupied by Stratford Place, Oxford Street. It is also recorded that at that period and in its immediate vicinity, the ancient church and village of *Tyborne* (now Mary-la-bonne), was also situated; and the

rivulet of *Tyborne* then flowed openly towards Tothill Fields, having over it a small bridge which derived its name from the Banqueting House standing near to it, on the north-east side. In the neighbourhood of this bridge, nine fountains or conduits were first erected in 1238, for supplying the City with salubrious water, and under the Banqueting House were two cisterns for the reception of the water. This was a handsome building, whither his Lordship, with his brethren, the Aldermen, occasionally repaired, *on horseback*, accompanied by their ladies, *in waggons*, to view the City conduits, after which they were sumptuously entertained in the said mansion house; but it having been for many years neglected by the Citizens, it was taken down in the year 1737, and the cisterns were arched over."*

White Conduit House also derives its designation from a white stone building, which formerly stood at a short distance from it, and covered a spring heretofore noticed. In former times the Charter House was supplied from this source by means of leaden pipes. When the tunnel of the Regent's Canal was formed, so as to pass under Islington, it occasioned the destruction of the spring, and the building over it has since disappeared.

The great fire which occurred in London, in 1666, proved destructive to several of the conduits. The following singular, but appropriate reflections of an eye-witness of that tremendous and memorable calamity, will, it is presumed, afford entertainment in the perusal, as well as exhibit a fair specimen of the quaint style of

* Maitland's *History of London*, p. 779. The hotel at the south-western corner of Stratford Place, in Oxford Street, is erected over these cisterns; and during a flood which happened a few years since, some of the arches were broken, and the lower part of the house was inundated.

writing commonly prevalent at the time. The work from which the extract is taken, consists of a series of discourses on a variety of subjects, treated in a similar manner:—

"As nature, by veins, and arteries, some great and some small, placed up and down all parts of the body, ministereth blood and nourishment to every part thereof, so was that wholesome water which was necessary for the good of London as blood is for the good and health of the body, conveyed by pipes wooden or metalline, as by veins, to every part of this famous City. If water were, as we may call it, the blood of London, then were its several conduits as it were the liver and spleen of that City; (which are reckoned the fountains of blood in human bodies,) for that the great trunks and veins conveying blood about the body, are seated therein as great roots fixed in the earth, shooting out their branches in divers and sundry ways: but alas! how were their livers inflamed, and how unfit have they since been to do their wonted office! They were lovely streams indeed which did refresh that noble City, one of which was always at work, pouring out itself when the rest lay still. Methinks these several conduits of London stood like so many little, but strong forts, to confront and give check to the great enemy fire, as occasion should be. There, methinks the water was intrenched and in-garrisoned. The several pipes and vehicles of water that were within these conduits, all of them charged with water, till by the turning of the cock they were discharged again, were as so many soldiers within these forts, with their musquetry charged, ready to keep and defend these places. And look how enemies are wont to deal with these castles, which they take to be impregnable, and despair of ever getting by them; that is, by attempting

to storm them by a close siege;—so went the fire to work with these little castles of stone, which were not easy for it to burn down (witness their standing to this day;) spoiled them, or almost spoiled them, it hath for the present, by cutting off those supplies of water, which had vent to flow to them, melting those leaden channels in which it had been conveyed; and thereby, as it were, starving those garrisons, which it could not take by storm. As if the fire had been angry with the poor old tankard-bearers, both men and women, for propagating that element which was contrary to it, and carrying it upon their shoulders, as it were in state and triumph; it hath even destroyed their trade, and threatens to make them perish by fire who had wont to live by water.*

Great as was the solicitude and interest formerly excited by the various conduits, at present scarcely any traces remain to indicate the precise places where they once stood, or the sources whence the water was derived, that flowed into them. That at Paddington, however, which was the first constructed, still exists, though probably not in its original form; but at a recent period it afforded a plentiful supply to some houses in Oxford-street. The conduit-head, or spring, is situate in a garden about half a mile to the west of the Edgeware-road, and the same distance from Bayswater, within two or three hundred yards of *The Grand Junction Water Company's* reservoirs. It is covered by a circular building in good condition; and the fact related above proves that some of the pipes continue in a sound state, though ages have elapsed since they were first laid down. From the same source, about a century ago, the palace at Kensington received a part of its supply, which was effected by the aid of a water-wheel, placed

* Rolle's *Account of the Burning of London, in* 1666.

The Conduit Head at Bayswater

at Bayswater-bridge, but on the establishment of the Chelsea Water-works it became useless, and was therefore removed.

The conduits at one period being so important to the inhabitants, the chief care and protection of them was confided to the principal magistrates of the City; and all the early writers who have noticed them, concur in representing the great attention bestowed upon their condition and preservation. Moreover it is recorded that endeavours were sometimes made to render them subservient to the purposes of moral instruction, even to royal personages. When James I. passed through the City on his accession to the English crown, "the unlettered bards" displayed their powers in "uncouth rhymes;" and though not exhibiting a "muse of fire," or "the highest heaven of invention," like the contemporaneous but matchless strains of the "immortal Shakspeare," or the "learned Jonson," yet some specimens of the doggerel effusions of the rudely ambitious "sons of song," may perhaps form neither an unappropriate nor unamusing conclusion of this chapter.

MORAL SENTENCES ON THE CITY CONDUITS.

"In a scarce and curious black letter duodecimo, printed in 1607, and intituled, *Strange Histories, or Songs and Sonnets of Kings, Princes, Dukes, Lordes, Ladyes, Knights and Gentlemen:* very pleasant either to be read or songe, and a most excellent warning for all Estats, are the following transcripts of *Moral Sentences,* which were set upon conduits in London against the day King James came through the Citie at his first coming to the Crowne."

Upon the Conduit in Grateous (Gracechurch) *Street, were these Verses—*

"Let money be a slave to thee,
Yet keepe his service if you can:
For if thy purse no money have,
Thy person is but half a man."

In Cornewall (Cornhill).

" To be wise and wealthy too
Is sought of all, but found by few."

" All on this world's Exchange do meete,
But when death's burse-bell rings, away ye fleete."

" When a Kinge's head but akes,
Subjects should mourne
For under their crownes
A thousand cares are worne."

" Bread earned with honest labouring hands,
Tastes better than the fruite of ill-got lands."

" He that wants bread and yet lyes still
It's sinne his hungry cheekes to fill."

" As man was first framed, and made out of clay,
So must he at length depart hence away."

" A man without mercy of mercy shall misse;
And he shall have mercy that merciful is."

In Cheapside.

" Life is a dross, a sparkle, a span,
A bubble: yet how proude is man!"

" Life is a debt, which at that day,
The poorest hath enough to pay."

" The world's a stage, whereon to-day,
Kings and meane men parts do play.
To-morrow others take their roomes,
While they do fill up graves and toomes."

" Learning lives and Vertue shines,
When Follie begs, and Ignorance pines."

" To live well is happinesse
To die well is blessednesse." *

* Brayley's *Reminiscences*, vol. i. p. 236.

CHAPTER II.

Various projects to remedy the defective supply of Water to London. Russel's scheme for conveying it from Uxbridge. Morice's first Water-wheel at London-bridge. Genebelli's proposal to Lord Burleigh. Bevis Bulmar's Horse Engine at Broken Wharf. New River. Plans of Forde and Sir Walter Roberts. London Bridge Water-works' Company. Southwark Water-works. York Buildings' Works. Mary-la-bonne Springs. Marchant's Water-works. Company of St. Alban's Waters. Increase in the number of Wheels at London-bridge: different improvements in the Works: their capacity and extent of Supply: final demolition for building the new bridge. Transfer of supplying the City to the New River.

The circumstances related in the preceding chapter show, that the supply of water to the metropolis for domestic purposes, was constantly the occasion of much solicitude, during a long series of years. It must likewise be evident, that the various contrivances to render it adequate to the wants of its great population, too often proved incompetent to realize this paramount object. The deficiency, however, generally prompted ingenious and enterprising men, to devise and propose schemes for increasing the quantity; and the diversity of their efforts will appear from a detail of several projects, which are mentioned by Stow, by his editor in 1633, and by Strype. The remark may likewise not be irrelevant, that the practice pursued in many other cities, of obtaining a partial supply from wells, by the bucket and windlass, was attended with considerable difficulty, on account of the great depth to the source of the water. Besides, though the common *lifting pump* had been invented early in the fifteenth century (in 1425); yet, in Elizabeth's reign, its use was

very limited; and some of them exhibited the whimsical taste of the persons who fabricated such structures.

One of the plans, noticed by Stow, is the following; and it is to be regretted, that his statement does not comprise some particulars respecting the mode by which the object was intended to be accomplished. "But before the New River was thus brought to the supply of the Citie, the projecting for the conveniency of water from the north side of the Citie was not out of the heads of the Citizens; for about the yeare 1580 odd (as I conceive it), there was one Russel, who propounded to bring it from Isleworth, *viz.* the river of Uxbridge to the said north of London: and that by a geometrical instrument, he propounded the invention in writing to the Lord Burghleigh."*

The next attempt was of a different description, and by being realized, laid the foundation for the London-bridge water-works. "Of later times Thames' water was conveyed into mens' houses by pipes of lead from a most artificial forcier standing neere to London-bridge, and made by Peter Morice, a Dutchman, in the yeere 1582 for the service of the Citie, and the eastern part thereof." † On the condition of his paying annually ten shillings into the chamber of London, it appears that the Lord Mayor and Commonalty of the City of London granted to this ingenious man a lease, dated May 30th, 1581, for a term of 500 years, by which he was authorized to erect an engine within the first arch of London-bridge, for the purpose of supplying the City with water. As this machinery completely effected its object, two years afterwards another lease for a similar term was also granted to him, for the use of the second arch; and the effects produced by this contrivance are thus described, in 1633:

* Stow's *Survey*. † *Ibid.*

A curious Pump in the yard belonging to Leather sellers Hall Bishopsgate supposed to be constructed in the time of Queen Elizabeth or James Ist. The Mermaid figure at the top was used on festal days as a fountain for discharging wine or other liquors from the breasts

J. R. Mackeley lith. 3 Wellington St Strand

"At present the supply of London with good water is like to be very much enlarged by the great improvement of the water-works of Peter Morice, before mentioned, who being a Dutchman, in the twenty-third of Queen Elizabeth, first gave assurance of his skill in raising the Thames' water so high as should supply the upper parts of London. For the Maior and Aldermen came down to observe the experiment; and they saw him throw the water over St. Magnus's steeple: before which time no such thing was known in England, as this raising of water." The same writer remarks, that "It is done by a mill, and was *the first water-work* that was made use of to supply the Citie of London with Thames' water:—and this water-mill furnished the neighbour parts of the Citie, as far as Gracechurch-street."* The small dimensions of the arches, and great breadth of the starlings, so much confined the flow of the river, as to occasion the fall to be several feet during the ebbing and flowing of the tides; hence, the velocity produced by this cause was sometimes very considerable.

All the contrivances of the Romans, as well as those heretofore adopted for supplying London, had evidently been formed upon the simple and well-known principle, that water will flow by its natural gravity along any channel that has the slightest inclination downwards. But the purpose of Morice's machinery was to impel the water in an ascending direction, and thus supply places much higher than its usual level. His *throwing water over St. Magnus's steeple*, must naturally have excited the wonder, as well as gratified the curiosity of the Citizens, for fire-engines had not then been invented; and although no particular description was given of the means

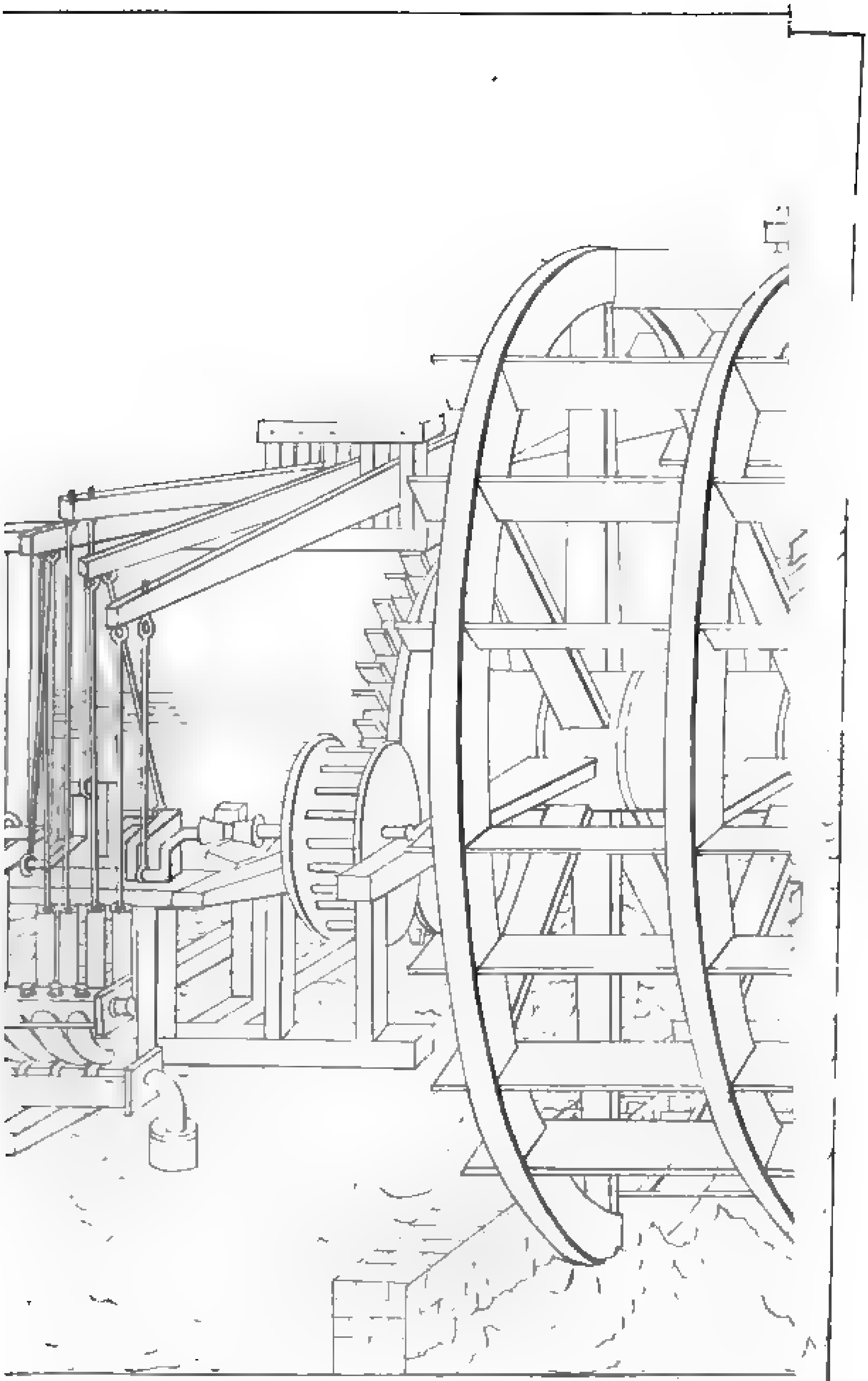
* Stow, Ed. 1633.

he employed to effect the object, it will be obvious that the use of the *forcing-pump* accomplished it.*

For a very minute account of the once greatly admired London-bridge water-works, the public are indebted to Mr. Beighton, an engineer, who carefully described them, and accompanied his detail with an engraving, which had proper references for its elucidation. It appeared in the *Philosophical Transactions* for the year 1731; but whether at that time all the works were precisely the same in form and action as those first constructed, or any improvement had occasionally been introduced, is not stated. The following summary contains the purport of Mr. Beighton's description; and it may be right to premise that the water-wheels and machinery, being fixed in strong frames of oak, they gradually rose and fell with the tides.

When Mr. Beighton wrote his description of the machinery at London-bridge, there were three water-wheels, of the respective diameters of nineteen and twenty feet, having axles of three feet diameter, and twenty-six float-boards, fourteen feet long by eighteen inches wide. The pumps employed had cylinders, with a length of four feet nine inches, and an interior diameter of seven inches above, and nine inches below the valve. The cylinders of the pumps were fixed to the top of an inclosed square iron cistern, which had appropriate apertures with valves, just below the places where they were attached. To one end of this cistern was also affixed a pipe, having a grating at the end, to prevent weeds or other things from entering it; and it extended into the bed of the river, for the purpose of supplying water to the pumps,—these being worked by cranks, which the revolving of the water-

* The forcing-pump was applied to construct fire-engines, in 1663.



...ving Lith. 3 Wellington St Strand

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wheels kept in constant motion, whenever the tides were flowing either up or down the river. One wheel communicated motion to sixteen pumps, and their cranks were arranged for four of them to work alternately, so that each set might draw its supply of water from the cistern in succession. Thus a comparatively small quantity of water only was conveyed into another inclosed square cistern, placed above the valves, and nearly parallel with the tops of the cylinders, and likewise connected with the pumps by bent pipes, having flanches; therefore, whenever the pistons of the pumps ascended, the water was forced along the bent pipes into the upper cistern, from which a large pipe conducted it to supply the houses. The latter pipe had an horizontal direction for some length, and then another was fixed to it, having a slight ascent, so as to form a very small angle; and these were fitted with valves to prevent the return of the water. One turn of all the wheels occasioned the whole of the pumps to make 114 strokes, and when the tide flowed quickly, it produced six revolutions in one minute, thus the total number of strokes in that short time amounted to 684, which raised 1954 hogsheads of water in one hour. Mr. Beighton suggested some improvements, and stated that such was the power of the machinery, that it would enable an ordinary man to raise fifty tons weight.

Besides the projects of Russel and Morice, as already noticed, another remarkable one appeared at that epoch. "An Italian, named Frederick Genebelli, also propounded an invention to the Lord Burghleigh for water-works for London, Anno, 1591, which should benefit the City two ways. First to cleanse the filthy ditches round about the City, such as Houndsditch, Fleet-ditch, &c. and to bring in the room of this filth, plenty of wholesome clear water, for the use of the inhabitants. Secondly,

to be an expedient for the speedier, and more effectual quenching of houses on fire, whereby twenty-five or thirty persons should do more than three hundred otherwise. And this Italian prayed the Lord Burghleigh to make known to the Queen on his behalf."* Though such obvious advantages were stated to be the result of this project if it should be realized, yet no particular description of it remains to show by what means the various purposes would be effected.

In 1594, with the view of supplying the western part of the City, a large horse-engine was erected within a short distance of Blackfriars-bridge, at Broken Wharf, by Bevis Bulmar. This machine gave motion to four pumps, and the conduit pipes immediately connected with them were made of very thick lead, with a large diameter. The expense attendant upon the operations of this concern being much greater in proportion to the supply than that of the other establishments, the proprietors were unable to furnish water at the same moderate rates, and therefore the want of encouragement occasioned the discontinuance of the works. Their site is now possessed by the *New River Company;* and whilst making the excavations, preparatory to the erection of their steam-engine, at a certain depth, the discovery was made of a large cistern, with its wooden trough communicating with the river. Various large and heavy leaden pipes, formerly employed in the above works, have likewise been discovered; and their weight amounted to many tons.

These statements afford cogent evidence, that, in the period referred to, when an important object gave the stimulus, there was no deficiency of projectors to propose plans for benefiting the inhabitants of the metropolis;

* Stow's *Survey*. Ed. 1633.

though inferior to the number distinguishing later times, with purposes and schemes almost infinitely various, as well as enormously expensive. Among those, however, which were successively devised during that era, one may be contemplated with peculiar satisfaction, because its utility has since been extensively experienced. The author of the subsequent narrative seems to have written it under the influence of very strong and indignant feelings.

"Next to the conduit water, was that famous (and never-to-be-forgotten) New River, brought from Chadwell and Amwell by the onely care, cost, and liberal expenses of one worthy man,—Master Hugh Middleton, Citizen and Goldsmith of London, deserveth to be recorded in everlasting remembrance.

"I spare here to speak of the length of time such an intent was in talking of, like much good matter well-motioned, though little minded, long debated, but never concluded, till courage and resolution lovingly shook hands together, as it appears in the soule of this (no way to be daunted) well-minded gentleman.

"For if those *Enemies* of all good *Endeavours*, *Danger*, *Difficulty*, *Impossibility*, *Contempt*, *Scorne*, *Derision*, yea, and *Desperate Despight*, could have prevailed, by their accursed and malevolent interposition, either before, at the beginning, in the very birth of the proceeding, or in the least stolne advantage of the whole prosecution, this Worke, of so great worth, had never been accomplished."*

The severity which pervades the preceding remarks, would seem to indicate, and certainly leads to the inference, that the scheme for constructing the New River aqueduct was strenuously and invidiously opposed, when it was first attempted to be carried into effect; but whe-

* Stow, Ed. 1633.

ther the hostility to its being realized proceeded from ignorance, a conflict of interests, or other causes, there are not any satisfactory means of ascertaining. However, one important consequence of its accomplishment is obvious; for it has occasioned the discontinuance of nearly the whole of the principal contrivances by which London was, in former periods, supplied with water.

In 1641 a Mr. Forde proposed a plan *for bringing a navigable river from Rickmansworth, in Harfordshire, to St. Gyles in the Fields;* and although some of its professed purposes were the conveyance of corn, timber, and other commodities to the London market, yet its principal and avowed object was to afford a larger and better supply of water to the inhabitants of London. It is also remarkable that among the various reasons assigned for this attempt, the most cogent was *the muddiness of the Middleton waters.* Thus it appears that at this early period of the New River Company's operations, those who ventured to become their competitors, adopted the practice of defaming the quality of the water supplied, in order to excite notice and obtain support for their own projects.

The scheme of Mr. Forde had likewise its opponents, and among them was a Sir Walter Roberts, who about the same time, brought forward another plan of his own. A principal feature of this project consisted in the construction of *a close conduit or aqueduct with brick or stone,* to convey water from Hoddesdon in Hertfordshire to Islington, where it was to be received into *a conserve,* or reservoir, in order to supply the inhabitants with pure soft water. However, no evidence remains of any attempt being made to realize either of the above projects, although both were accompanied with a flattering display of the pecuniary, as well as other advantages, which would infallibly result from their accomplishment. The

citizens of London being then neither so numerous nor so wealthy as in later times, and perhaps less inclined to engage in large speculations, the plans received but little countenance from the public; and were therefore probably abandoned from the want of the large sum of money necessary for carrying them into effect.

In the year 1691, water-works were constructed for supplying a part of Westminster; and the persons who engaged in this undertaking obtained an Act of Parliament for incorporating them by the designation of "*The Governor and Company of Undertakers for raising Thames' water in York Buildings.*" The establishment was situate on the bank of the river, contiguous to the Strand, at the bottom of Villiers-street, under which their principal cistern or reservoir extended. These works conveyed water as far as Piccadilly, Whitehall, and Covent Garden, with the intervening streets; but the greatest number of houses that at any time received a supply from this concern was about 2700.

The original number of shares consisted of eighty-four, at 100*l.* each, making a capital of 8400*l.*; but this sum, proved inadequate to the attainment of their object, and after contending with difficulties till June, 1734, the company issued 242 bonds for various sums, amounting altogether to 13,053*l.* 1*s.* 3*d.* at three per cent., for the purpose of paying certain creditors. In 1746, the proprietors discontinued to manage the water-works as a company, but let them on a lease for twenty-one years, at an annual rent of 250*l.*, and renewable at the expiration of that term. Subsequently they were leased for a term of ninety-nine years, from Midsummer, 1767, for the same annual rent. In 1810, the number of shares was increased to 750, of 100*l.* each; but in 1812, even this last number was doubled by the persons, who had

become proprietors. The latter conceiving that by a different system of management the concern might be improved, the whole of the wooden pipes were taken up and iron mains substituted in their place. A large steam engine was also erected, and a more capacious conduit laid in the bed of the river for obtaining a greater quantity of water. Previous to this period 30,000*l.* had been expended upon the works, but the improvements occasioned an annual loss of 1500*l.* a year, for their rental had never much exceeded 4000*l.* From 1789 to 1801, the dividend on each share varied from 10*l.* to 7*l.* 10*s.*; in 1804 it was 4*l.* only; but in the interval between that time and 1810, no more than two dividends of 1*l.* each were paid; and as no profit had accrued, the money for the purpose was abstracted from the capital.

The affairs of the company thus gradually deteriorating, they resolved to dispose of their interest in the works, which were accordingly conveyed by a lease to the New River Company for 2000 years, on their paying to trustees of certain lessee proprietors 250*l.* 18*s.* 6*d.* annually, by half yearly payments; and likewise the annual sum of 2000*l.* for ninety-three years. This indenture is dated the 16th of September, 1818, and it stipulated that the first payment should be made in March, 1819, and the last in June, 1911. The district formerly supplied by the York Buildings' Works, is now divided among the New River, Chelsea, and Grand Junction Water Companies. Besides, an act of parliament was obtained in 1829, to authorize the dissolution of the York Buildings' Company, and also to effect the sale of every kind of property belonging to it, so that the produce might be finally divided amongst the proprietors.

Referring to the original agreement with the corpora-

tion for establishing water-works at London Bridge, Strype observes, that—"This lease and the business thereof, continued in the family of the Morices till Michaelmas, 1701. When the present owner, perceiving how the New River undermined him, and impaired his profits, he agreed to sell all his right and title to Richard Soams, citizen and goldsmith, of London, for the sum of 38,000*l*. But Soams foreseeing that he should have need of another arch for more water, Morice, the better to enable Soams to go through with this great bargain, petitioned the city for another arch to raise more water. Hereupon there were several committees appointed to examine whether the granting the fourth (for the third belonged to a wharfinger) would not incommode, and be a stoppage to the river. But they brought in their report, that it would be no damage to let the fourth go to this use. And it was granted to Morice, and he added his whole interest in this grant of the fourth arch to Soams's bargain.

"Thus having gotten through with Morice, he took a lease of the city at 20*s*. and 300*l*. fine, for so much time as was unexpired of the 500 years granted to Morice. And now Soams hath divided the property of the lease into 300 shares, and made it a company; the price of each share being set at 500*l*. And so the profits to be divided. It hath a good prospect of turning to account, and to gain upon the New River, having some advantage of that water." In this statement, the origin of the London Bridge Water Works' *Company* is developed; but another company attempted to establish a similar kind of water-works on the Southwark side of the bridge, as appears in the following detail:—

"So on Southwark side, for the furnishing that borough with good water, some gentlemen took a lease of the

city waters arising that way, at 550*l.* fine, and 250*l.* a year. But after all their pains they could find no water sufficient for their purpose that way; and so the Lord Keeper discharged them upon their inability. Southwark useth chiefly the water of the Thames, that falls into a great pond in St. Mary Overies, that drives a mill called St. Saviour's Mill. The owner whereof is one Mr. Gulston. The revenue thereof is supposed by some to be worth 1300*l.* a year."*

Some other establishments likewise existed formerly for the purpose of supplying the inhabitants of the metropolis. The object of one of them was to supply the city with *spring* water; and it appears that Soams, who possessed the London Bridge Works, was engaged in it. "There is another water for the supply of the city, called Maribone Water, because it comes from Maribone; and several other conduit waters there be, which the city let to certain persons, at 700*l.* a year, and 5650*l.* fine, and a year's rent aforehand. These lessees had made a very hard bargain for themselves, and my Lord Keeper discharged them of it. Now the city hath let all these conduit waters to the aforesaid Soams, at the former rent of 700*l.* a year, tax free. And so he hath within himself and his partners, all the waters that supply the city, except the New River. In this lease also the city hath reserved to themselves the proportion of five ton an hour of the said conduit water, for the use of the prisons and counters, and other public places. Though it hath been thought by some, that all the waters of those conduits would hardly afford so much."†

Maitland mentions another establishment, called Merchant's Water Works, which had "three engines, viz.

* Stow's *Survey*, edited by Strype, 1720.
† Ibid.

a windmill in Tottenham Court Field, and two other wrought by the common sewer, at Toms' Coffee House, in St. Martin's, and Hartshorn Lanes, in the Strand, whence issue three mains of six and seven inches bore, whereby those neighbourhoods are supplied from six fountains, or wells at Tyborne."*

In the year 1730, there appeared a project which is remarkable for its striking resemblance to some of those propounded at a later era. At that period a bill was actually produced into parliament, to form a company and construct works for supplying the Cities of London, Westminster, and the parts adjacent, with water from the river *Colne*, Gade, Bulborne, Chesham Water, and the Lea, under the designation of "*The Company of St. Alban's Waters.*" Although the scheme was sanctioned by the names of various titled personages, it seems to have failed like many of its precursors, and perhaps from similar causes. The presumption may not be improbable that its failure also discouraged other persons, entertaining congenial views, from making any attempts of the same kind for a long time afterwards.

At a subsequent period, with the view of erecting some additional water-wheels to augment the efficiency of their supply to the city, the proprietors of the London Bridge Works, obtained from the corporation, leases of the third and fifth arches. As the fifth arch was situate on the Southwark side of the bridge, it occasioned the wheel erected contiguous to it to be denominated *The Borough Wheel.* The lease for the *third* arch, having a term of 321 years, is dated September 29, 1761:— the other for the *fifth* arch from the *north*, and second

* *Hist. of London*, p. 628.

from the *south* end of the bridge, has the term of 315 years from its date, September 29, 1767; hence, all the leases granted by the corporation for these works, will terminate nearly at the same time.

The supply of water from the London Bridge Works extended over a large portion of the city of Southwark. It was effected by the use of six large water-wheels; and the machinery connected with them raised the water from the river, as well as forced it along the wooden pipes, laid along the streets for conveying it to the houses. It may be deserving of remark, that all the wheels were originally constructed with wood, as well as repaired with the same kind of materials till the year 1817, when an *iron* wheel of great magnitude was substituted for one of them, at the expense of 6500*l*., and afterwards another which cost 5000*l*. These proved to be so considerable an improvement in augmenting the power of the works, that during the year 1821, the average quantity of water daily supplied, was estimated at nearly four millions of gallons, but though this might be the ordinary amount, yet in seasons when the tides were very low, the water-wheels proved inefficient, and the great deficiency in the necessary supply, required the use of a steam-engine to pump water from a point near to the middle of the river.

Admirable as might be the London Bridge Works for the ingenuity displayed in their original contrivance and construction, nevertheless, they eventually became incompetent to effect some desirable purposes required by the progressive introduction of various improvements. The principal of these arose from building many houses in the city very lofty, and furnishing the rooms in different stories, even to the highest, with washing and other conveniences. As a plentiful supply of water was

essential for the use of each, to convey it to the height of some of them, rendered indispensable the aid either of very elevated reservoirs, or more powerful machinery than that possessed by the London Bridge Works. But the low state of their funds prevented the proprietors from contemplating the attainment of such costly objects; and if a deficiency of pecuniary means had not proved an insuperable impediment to their desire of making necessary improvements, there existed a very great difficulty, if not an almost impossibility, of procuring proper sites for the construction of reservoirs, or the erection of large steam-engines. Besides, even if they could have obtained the situations best adapted to that purpose, from their being probably covered with buildings, the amount of the purchase would consequently be so enormous as to make the attempt on their part unavailing.

Other causes also had some influence in discouraging any disposition to incur expense in making improvements, and at the same time tended to depress the value of the establishment; but the circumstance that chiefly affected their prosperity, was the New River Company having their iron pipes laid down through nearly the whole range of the city, and likewise being in possession of all the means for abundantly conveying water to any desired elevation. Thus the power of immediately affording an ample supply wherever it might be required, invested them with peculiar advantages for obtaining a preference which greatly diminished the number of the London Bridge Company's tenants. Hence, these and various concurring circumstances, powerfully operated against the success of the London Bridge Works, so as eventually to render them unprofitable, that their discontinuance would perhaps have been the inevitable consequence

if erecting the present new bridge had not occasioned their removal.

Although the water-works at London Bridge have ceased to exist, yet, for a long period, a considerable portion of the inhabitants of the city, both experienced and acknowledged their utility; but their locality, as well as some other disadvantages, equally conspired to affect their ultimate welfare. The source and means of obtaining the water, as well as its immediate conveyance for use, commonly in a turbid state, and often very muddy, had a tendency to produce unfavourable impressions, exclusive of other cogent reasons of a different kind. Nearly the whole of their pipes being wood, they were incapable of sustaining the pressure necessary for conveying water into the higher stories of many houses, even in situations where the water-wheels had sufficient power to force it to the required altitude. For such a purpose *iron* pipes were indispensable; but the same want of pecuniary means, which prevented the proprietors from constructing elevated reservoirs, and erecting large steam-engines, likewise disabled them from adopting the extensive use of iron pipes. Deficiency of capital, therefore, proved an insuperable obstacle to any feasible efforts to place themselves in a proper condition for successfully contending with more powerful competitors. Besides, at the period when the other water companies were established, and laying down iron pipes, the erection of the New London Bridge was in contemplation. This circumstance probably had considerable influence on the decisions, as well as concurred with the indigence of the company in suggesting the propriety and advantage of refraining to engage in any expensive attempts to effect improvements. Events have demonstrated the wisdom of this precaution, for the building of the new bridge

has occasioned the annihilation of the water-works, which had essentially served the purposes of a large and populous city for centuries. The wheels and other machinery having been altogether removed, those houses which formerly received their supply of water from this source, now derive it from the New River, and East London Works.

When Mr. Soams had completed his purchase of the London Bridge Works, with all their concomitant advantages, it has been already stated, that he divided the whole property into 300 shares of 50*l.* each. Subsequently, however, another division of it was made into 1500 shares of 100*l.* each; and these fluctuated so much in their value, that their gradual deterioration occasioned them to be sold at 50*l.* each, only a few years previous to the final termination of the concern. The following statement will show the extent of their operations a short time before the final destruction of the works. According to the return made to the parliamentary committee in 1821; the annual rental derived from them was 12,266*l.*; the number of houses supplied, 10,417:—and the quantity of water 26,322,705 hogsheads.

Previous to the demolition of the works, the persons then possessing the property, transferred all their leases derived from the city to the New River Company for the consideration of 3750*l.* payable annually for 260 years, being at the rate of 2*l.* 10*s.* for each share. Besides the Act of Parliament obtained by the Corporation in 1822, for the purpose of removing the old bridge, and erecting a new one, contained a clause, which sanctioned the conveyance of a portion of the tenants formerly supplied from London Bridge to the East London Company, on the condition of the latter paying to that of the New River, an annuity of 160*l.* for the period of

260 years. That part of the Southwark, which had previously received its supply from the London Bridge, was also conveyed to the proprietor of the Borough Works for an annual consideration of 1060*l.*

It may be confidently stated, that the supplying of water to the city, from the New River, has proved advantageous to its residents, for the supply is not only more abundant than formerly, but also more regular at all seasons of the year, and in every situation, whatever may be its altitude. Exclusive of the ready and effective assistance afforded by this company in cases of conflagration, or other emergencies of a serious nature, their rates are very low, amounting merely to about one farthing the hogshead. Indeed, the completeness of their operations, enable them in a high degree to serve and benefit the community; and their exertions evidently facilitated the removal of the London Bridge Works, which, to a certain extent, had actually become a nuisance upon the river. Besides, if even in a pecuniary point of view, their own interests may have been promoted by the change, nevertheless, the service thus rendered to the public is, perhaps, very inadequately compensated by the emolument resulting from efforts equally useful and important.

CHAPTER III.

Circumstances relating to the original construction of the New River. Acts of Parliament for the purpose. Pusillanimity of the Corporation of London. Enterprising spirit of Sir Hugh Myddelton: engages to construct it at his own expense: his great difficulties and refusal of the Corporation to render him any assistance. Pecuniary means for Completing the Works afforded by James I. Rejoicings on the occasion of Water first entering the Reservoir at Clerkenwell. Mr. Robert Mylne's monumental erections to the Memory of Sir Hugh Myddelton at Amwell, with Inscriptions. Place of his Birth, and pecuniary circumstances at the time of his Death.

NOTWITHSTANDING the number of conduits erected at different times in various parts of London, as well as the other modes adopted for supplying water to its inhabitants, the quantity proved inadequate to the demands of a constantly increasing population. But among the diversity of schemes for obviating complaints and effecting this important purpose, during the reigns of Queen Elizabeth and her successor James the First, one is entitled to particular notice, inasmuch as it subsequently led to the construction of the New River.

In the latter part of the reign of Elizabeth, the Corporation of London obtained an Act of Parliament to empower them to cut a river for conveying water to the city from *any part* of Middlesex, or Hertfordshire; and *ten years* was the time specified for the execution of the plan. Although legal authority was thus actually procured, yet either a deficiency of capital, or the absence of an ardent spirit of enterprise, prevented any efforts being made to realize the project. Circumstances, however, occasioned the

same object to be kept in view, and another attempt was made to attain it, in the third year of the reign of James the First, 1606. In this instance an Act was procured to enable the Corporation to bring a stream of pure water, from the springs of Chadwell and Amwell in Hertfordshire to the City of London; but some of the provisions of this Act being found defective, they were rectified by another in 1607. Necessity and policy seemed to dictate the prompt execution of this desirable scheme, nevertheless it is remarkable that, even on this occasion, the apparent difficulties attending it, again deterred the citizens from proceeding to realize their original intentions. How striking is the contrast between such vacillating and pusillanimous conduct, and the bold, enterprising propensities evinced by their successors, during the last fifty years! The magnificent works either constructed, or in the course of being executed for benefiting the public, demonstrate that neither difficulties, nor pecuniary cost, can interpose obstacles to prevent the accomplishment of great and useful undertakings in the City of London.

Though timidity or prudential considerations restrained the Corporation from engaging in the admirable and laudable enterprise of forming the New River, and their conduct consequently occasioned some delay in commencing the operations for the purpose, yet the arduous attempt was eventually made by that ingenious and magnanimous individual—"Master Hugh Myddelton." Circumstances also lead to the presumption of his having been principally instrumental, in prompting the Citizens of London to apply for the two Acts of Parliament mentioned above; but whether this was really the fact or not, he was evidently a person possessing great mental and bodily activity, adapting him for aiming at and effecting important objects. Among other circumstances, it is related

that he had acquired considerable riches by the produce of some copper or silver mines, in Wales; and probably the successful results of his previous speculations, emboldened him to propose to the Common Council, the hazardous adventure of constructing the New River solely at his own risk and expensee;—engaging also to begin his operations within two months from the time a transfer should be made to him, of the authority which was invested in the Corporation, by the two Acts of Parliament. Happily for the public, but unfortunately for the pecuniary welfare and prosperity of this public-spirited man, his proposal was acceded to; and an Act of the Common Council, dated the 28th of March, 1609, authorized the conveyance to him of all the power necessary for his purpose. As a consequence to this preliminary measure, the agreement was afterwards completed by an indenture bearing the date of the 21st April, 1609. Thus the legal engagement with him was finally arranged for effecting this desirable and important work for the future benefit of the community; and the utility of the undertaking has probably far exceeded the utmost anticipations indulged by its original projectors.

The necessary legal powers for realizing his purpose being secured, Mr. Hugh Myddelton immediately commenced his operations, and proceeded with a spirit commensurate to their importance. His progress at first was unavoidably slow, from a variety of causes concurring to retard his career, but the principal impediments arose from the harassing opposition of various persons, who were proprietors and occupiers of the lands, through which it was indispensable that the stream of water should be conducted. Besides, at that period the science and practice of civil engineering were comparatively little known in this country, and hence, probably his deficiency

of knowledge might occasion some difficulties in surmounting obstacles, which, at the present time, would be easily overcome. Suffice it to state that a complication of vexatious circumstances led to many interruptions and delays, which constrained Mr. Myddelton to petition the Corporation for an extension of the period, specified in the original agreement for completing the undertaking. This request was so reasonable, that both justice and policy dictated a cordial acquiescence on the part of the Corporation; and they consequently, after due deliberation, readily granted the additional time required.

Although this concession removed one difficulty, yet troubles of a different kind and more serious in their consequences, attended the exertions of this meritorious man, exposing his noble and intrepid spirit to a very severe trial. Having amicably and satisfactorily terminated his contentions with all the landholders, and the canal also being completed so far as to convey water to the vicinity of Enfield, his funds became quite exhausted, by the expense proving much greater than he had anticipated. As he found himself unexpectedly impoverished, necessity obliged him to apply again to the Corporation, with the view of inducing them either to take an interest, and engage as principals in the execution of the work, or to afford him that pecuniary assistance which would enable him to complete an enterprise so laudably begun. However, its having proved so very expensive, and the uncertainty of its profitable results, were such unfavourable circumstances in the estimation of the citizens, as prevented their acceding to his proposals. This refusal of the Corporation, under such harassing and distressing exigencies, to help and support him to continue his exertions, was peculiarly mortifying to his generous and enterprising disposition. Hence, to obtain relief, he was impelled to make

an application to James I. and importune him to furnish the requisite means for proceeding with and completing the undertaking. Fortunately the attempt proved successful, and the King agreed to afford the necessary pecuniary assistance, stipulating as a security, that a moiety of the whole concern should be conveyed to him, and on this being done, he consented to pay the expense of all that portion which remained to be executed. The necessary funds having been thus obtained, Mr. Myddelton proceeded with his operations without any farther interruption, till the project was ultimately completed, according to his original agreement; and on the 29th day of September, 1613, the water entered the reservoir, now denominated the New River Head, in the parish of Clerkenwell.

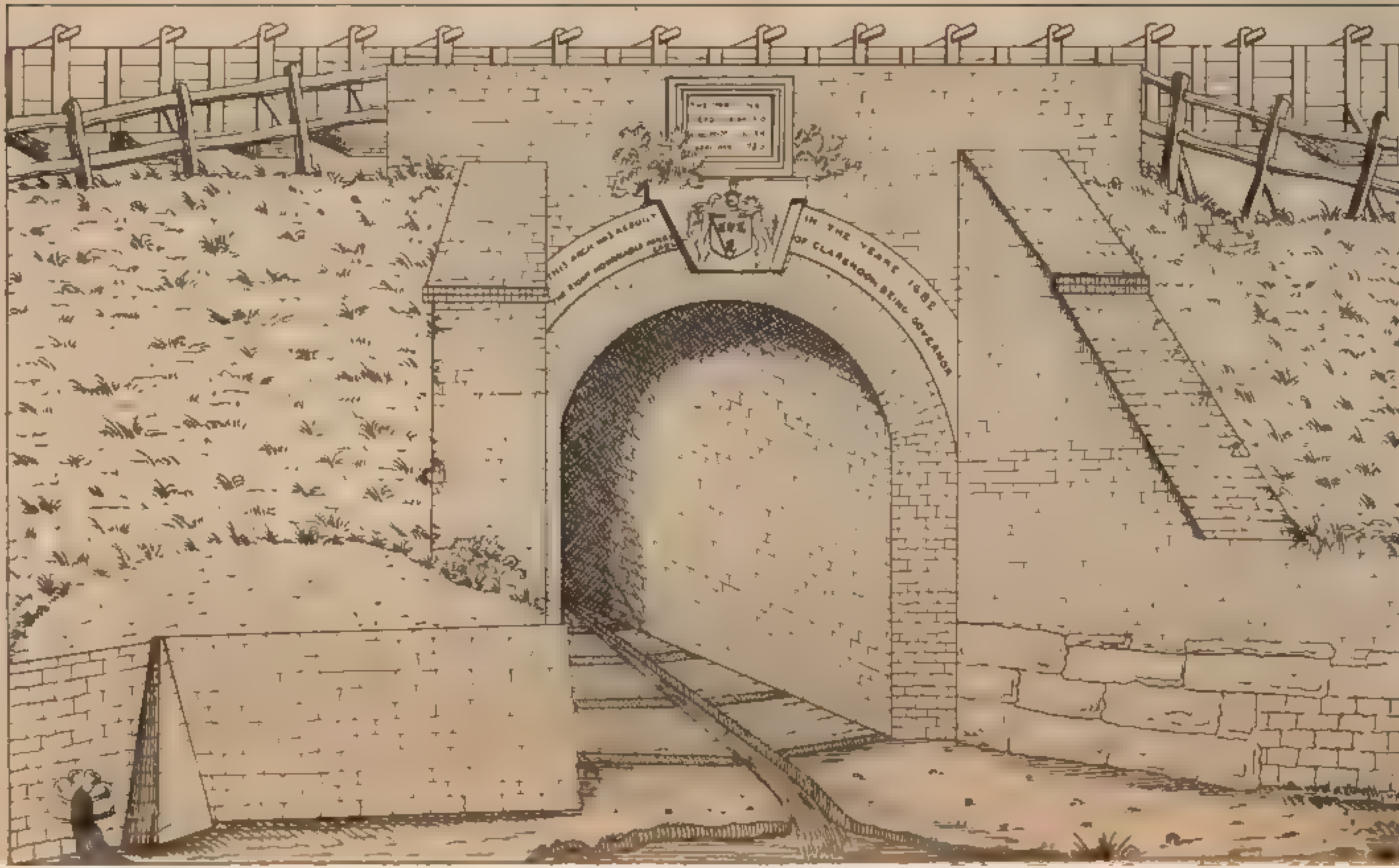
The construction of this extensive and useful aqueduct being the first of its kind in England, it not only excited much curiosity, but was the theme of admiration and applause at the period of its accomplishment. Indeed to surmount the difficulties which Mr. Myddelton had to combat, required no ordinary share of talent, intrepidity, and perseverance; and the subsequent short detail will evince, that the execution of such an enterprise, in that age, was not only very arduous, but actually deemed wonderful.

" The depth of the trenches, in some places, descended full thirty feet, if not more; whereas in other places it required a sprightful arte again to mount over a valley in a trough between a couple of hils; and the trough all the while borne up by wooden arches, some of them fixed in the ground very deep, and rising in height above twenty feet." * One of these troughs, or wooden aqueducts was

* Stow's *Survey*, Ed. 1633.

constructed near to Bush Hill, in the parish of Edmonton. Its length was 660 feet, and width and depth five feet. It was tied together by imposts, seven inches by three inches; and the uprights were eight inches, by four inches, with a height of six feet, like buttresses: these rested on eighty brick piers two and a half feet high; though not erected at equal distances. Between every two of the latter, an equal number of imposts and uprights were fixed, resting in fills of similar dimensions, on the basement timbers of the frame. This trough was lined with lead, and in 1725, with all its appendages of wood, &c., was raised one foot higher than at its original construction. It passed over a stream which had its source in Enfield Chace, and flowed through an arch being fifteen feet high to its crown, and three feet wide. The arch sustained the trough, and the road along its side.

Formerly a similar wooden aqueduct conducted the New River over a valley, near the place where it enters the parish of Islington. This trough was lined with lead, and had a length of 462 feet, with a height of seventeen feet. It was supported by very strong timber uprights which rested on brick piers, and it was commonly denominated *the boarded river*. As these structures were almost continually requiring repairs, and their defects occasioned a great loss of water, the company found it expedient to remove them, from the expense of repairing, as well as the waste of water, being so very considerable. The removal of that at Islington was effected during the years 1776, 1777, and 1778, by raising a bed of clay and earth to the proper height, so as to be level with the top of the trough, and thus form a bed and channel for the river in its usual track. Particular care was bestowed upon the banks for the purpose of preventing the water oozing through, as well as to strengthen them


IN THE YEARE 1682

by sowing grass down their sides; and a thick bed of gravel was also laid on the top of that on the west, to form a pleasant path. The wooden aqueduct near Bush Hill was likewise removed, and a channel made for the river, by similar means, during the years 1784 and 1785. Both these improvements were made under the superintendence of Robert Mylne, Esq., then Engineer to the New River Company.

The above contrivances, among others, indicate that a considerable share of ingenuity and mechanical skill were called into exercise during the progress of this useful work. Its completion was celebrated with some very joyous proceedings, and a contemporary who witnessed them, and participated in the pleasure, has given the following minute description of the ceremony on the occasion:—

"Being brought to the intended cistern, but not (as yet) the water admitted entrance thereinto; on Michaelmas day, anno 1613, being the day when Sir Thomas Middelton, Knight (brother of the said Hugh Middelton) was elected Lord Maior of London for the year ensuing: in the afternoon of the same day, Sir John Swinerton, Knight, and Lord Maior of London, accompanied with the said Sir Thomas, Sir Henry Montague, Knight, the Recorder of London, and many of the worthy Aldermen, rode to see the cistern, and first issuing of the river thereinto which was performed in this manner:

"A troop of labourers, to the number of sixty, or more, well-apparelled and wearing green *Monmouth* caps, all alike, carried spades, shovels, pick-axes, and such like instruments of laborious employments, marching after drums twice or thrice about the cisterns, presented themselves before the Mount, where the Lord Maior, Aldermen, and a worthy Company bedside, stood

to behold them; and one man (in behalf of all the rest) delivered this speech.

"The speech at the cistern according as it was delivered to me:—

"Long have we laboured, long desir'd and pray'd
For this great work's perfection; and by th' aid
Of Heaven, and good men's wishes 'tis at length
Happily conquered by cost, art, and strength,
And after five years' dear expense in days,
Travail and pains, beside the infinite ways
Of malice, envy, false suggestions,
Able to daunt the spirit of mighty ones,
In wealth and courage, this work so rare,
Only by one man's industry, cost and care,
Is brought to blest effect, so much withstood,
His only aim the citie's general good.
And where (before) many just complaints
Enviously seated, caused oft restraints,
Stops and great crosses to our master's charge,
And the work's hindrance: favour now at large
Spreads itself open to him, and commends,
To admiration both his pains and ends.
The King's most gracious love. Perfection draws
Favour from princes, and (from all) applause.
The worthy magistrates, to whose content,
(Next to the state) all this great care was bent,
And for the public good (which grace requires),
Your loves and furtherance chiefly he desires,
To cherish these proceedings, which may give
Courage to some that may hereafter live,
To practice deeds of goodness and of fame,
And gladly light their actions by his name.
Clerk of the work reach me the book to show,
How many arts from such a labour flow.

All this he readeth from the Clerk's Book.

First, here's the overseer, the tried man,
An ancient soldier, and an artisan,
The clerk, next him, mathematician,
The master of the timber-work takes place
Next after these; the measurer in like case,
Bricklayer and engineer, and after those,
The borer, and the pavier. Then it shows

The labourer next; keeper of Amwell-head,
The walkers last: so all their names are read.
Yet these but parcels of six-hundred more,
That (at one time) have been employed before.
Yet these in sight, and all the rest will say,
That all the week they had their royal pay.

At the opening of the Sluice.

Now for the fruits then:—Flow forth, precious spring,
So long and dearly sought for, and now bring
Comfort to all that love thee: loudly sing,
And with thy crystal murmurs strook together,
Bid all thy true well-wishers welcome hither."

"At which words the floodgates flew open, the stream ran gallantly into the cistern, drums and trumpets sounding in triumphal manner; and a brave peal of chambers gave a full issue to the intended entertainment.*

The above detail shows that this useful work was an object of extraordinary interest to the citizens of London in those days; and, as

"One self-approving hour whole years outweighs,
Of stupid starers, and of loud huzzas."†

the rejoicings with which the final completion of the aqueduct was celebrated, must have been unspeakably gratifying to Sir Hugh Myddelton, by demonstrating the high and appropriate estimation of his magnanimous views and incessant exertions for the public advantage.

The accomplishment of this important and stupendous project has immortalized the name of Hugh Myddelton, by enrolling it among the great benefactors of mankind. In realizing a scheme so laudable, his perseverance, fortitude, and industry, afforded an instructive and encouraging example to the community of which he was a member. Besides, the striking and extensive utility of his efforts, eminently entitle him to the grateful remem-

* Stow's *Survey*, 1638. † Pope.

Various trees and shrubs are planted on the islet where the pedestal stands, and amongst them the weeping willow with its drooping branches, appears conspicuous. The cedar, the cypress, the yew, and other evergreens, surround and cover a *tumulus;* and besides the above inscriptions there are the following verses, written by the late Archdeacon Nares:—

> "Amwell! perpetual be thy stream,
> Nor e'r thy springs be less,
> Which thousands drink who never dream
> Whence flows the boon they bless.
>
> "Too often thus ungrateful man,
> Blind and unconscious lives,
> Enjoys kind Heaven's indulgent plan,
> Nor thinks of HIM who gives."

The perusal of Sir Hugh Myddelton's *will,* has a tendency to prove the incorrectness of some of the statements, commonly made by his biographers, concerning his *indigence,* after completing the New River, as well as the place of his birth. The latter is ascertained by his bequest of "20*l.* to the poor of *Henlan,* in the county of Denbigh, *where he was born.*" That he materially diminished the amount of his wealth by attempting to construct the New River at his own expense must be acknowledged; nevertheless, at the time of his decease, he possessed about twenty shares in the concern, beside other property of various kinds; for, to his wife he bequeathed thirteen shares—his house at Bush Hill, Edmonton, with all the furniture, plate, jewels, &c. and to descend to his younger son, Simon, after her death. He had four sons and three daughters:—and to two of the latter he bequeathed each a share, accompanied by legacies of 500*l.*—to three of his sons also each a share, attaching to one a legacy of 400*l.*—to another a legacy of

only 100*l.*, "having given him his share during his life." —To one daughter, "who had her full portion on her marriage," he gave only 10*l.* to buy rings for her and her husband; but to a younger he left 1000*l.*, with an additional 900*l.* on the performance of certain conditions, by her husband's relation, because he was not of age. Nearly twenty legacies were left to others, varying in their sums from 50*l.* to 5*l.*, but the greater number consisted of 30*l.* and 20*l.*, besides 5*l.* each to every one of his servants, excepting two, who had only 40*s.* To these bequests may be added, the "one share in the New River to the Goldsmiths' Company, in trust, the profits to be distributed every half year, after the death of his wife, in weekly portions of twelve pence each to the poor of the said company, by the discretion of the wardens for the time being, and especial to the poor of his own name, kindred, and country." He likewise possessed "shares in the Mines Royal in Wales," which he directed "to be sold to pay his debts;" and, "if they did not prove sufficient, then some of the shares or parts of shares in the New River to be sold to make good the deficiency." The date of his will is November 21, 1631; but he did not die till 1636, and at that time the income of the New River property was greatly improving; for, although in 1633, the dividend on each share amounted merely to 3*l.* 4*s.* 2*d.*, yet, in 1640, it had risen to 33*l.* 2*s.* 8*d.*; and in 1680, had increased to 145*l.* 1*s.* 8*d.* Hence, these facts may perhaps justify a conclusion that Sir Hugh Myddelton did not die in very indigent circumstances, whatever misfortunes or privations happened to his family at a subsequent period.

CHAPTER IV.

Advantages of the New River to London. Original cost of its construction. Charter granted to the Company, and powers conferred by it. Commissioners for annually inspecting the condition of the New River. Its length, width, depth, and fall. Number of bridges erected over it. Sources of water for its purposes. Balance engine at the river Lea. Height of reservoirs. Machinery. Boulton and Watts' Steam Engine: its Register. Miles of wooden pipes: their disadvantages. Use of iron pipes adopted: their great strength and efficiency. Extent of district, number of houses, and quantity of water supplied. Steam Engine at Broken Wharf. Situation and dimensions of different reservoirs. Mode of clearing the water before it flows to the cisterns of the inhabitants. Gratuitous offer to supply it for the purposes of free baths. Amount of capital expended in forming and improving the works. Settling reservoirs at Stoke Newington.

The various facts that have been narrated clearly show that, prior to the construction of the New River, the inhabitants of London experienced serious inconveniences from the defective supply of pure spring water, exclusive of the trouble generally attendant upon the mode of procuring it. Besides, sometimes the deficiency excited serious uneasiness and alarm, from the quantity being quite insufficient for their usual and indispensable wants, which was commonly the case during very dry seasons, and long and severe frosts. When occasions of this kind occurred, the humbler classes became peculiarly exposed to privations and suffering, from their inability to obtain a sufficiency for culinary purposes and domestic beverage; but the forming of that extensive aqueduct rendered a plentiful supply attainable during all seasons, and effectually

obviated the difficulty and distress resulting from those exigencies. Moreover, the contrivances and arrangements adopted for conveying any quantity, directly into the respective habitations, was also an essential improvement, inasmuch as it diminished the laborious drudgery of servants, who often found the fetching of a pitcher of water from the conduits an unpleasant occupation, from the great number of people assembled there, waiting for their turn to procure it.* Similar disadvantages are still evident in those large towns which do not possess water-works for supplying the inhabitants; and such places exhibit a striking contrast to the commodious, ready, and abundant means for supplying London and its suburbs.

Though the operations for constructing the New River were limited to the term of five years, it was completed within that period, notwithstanding the various obstacles and difficulties encountered in the progress of its execution. From the destruction of the documents by fire, the original cost of the undertaking cannot now be exactly ascertained; but various estimates which have since been made, evince that it must have amounted to between one and two hundred thousand pounds. Though so large a sum of money was expended upon it, and its obvious utility to the public, yet a long time elapsed before it yielded profit, in a remote degree, proportionate to the importance of the object obtained by its expenditure.

* The evils attendant upon these assemblages and mixture of servants, are experienced at Paris and other great cities; for at such indiscriminate meetings of different persons, robberies are often concerted, intrigues carried on, and the tittle-tattle of gossips not unfrequently becomes circulated, so as to produce discord and vexations in families. Probably these formerly existed to a considerable extent in London.

During the first nineteen years after it was finished, the pecuniary results afforded merely sufficient for a trivial annual dividend of about 13*s.* upon each share; but no dividend whatever was made till the year 1633, when the concern seems to have become rather more productive, and consequently the above average dividends for the whole period, including 3*l.* 4*s.* 2*d.* for that year, amounted to 15*l.* 3*s.* 3*d.*, which was then paid to each shareholder.

The New River Company was incorporated by a charter in the reign of James I., bearing the date of June 21st, 1619; and by its provisions, the proprietors consist of two distinct classes, which derive their distinctions from the original division of the property, when the whole was separated into two moieties, each being composed of thirty-six shares: one of the moieties being designated the King's, and the other the Adventurers'. The whole property is freehold, and the shares being made divisible, some of them are at present subdivided into several different parts. The management of all its affairs is exclusively vested in the holders of twenty-nine Adventurers' shares, who elect a governor, deputy governor, treasurer, and clerk, the charter constituting them the chief officers of the corporation.

"On account of the unpromising aspect of the company's affairs, Charles I. re-granted to Sir Hugh Myddelton, his heirs and assigns, the moiety of the undertaking, on condition that they should pay the receiver-general, or into the receipt of Exchequer, 500*l.* annually, which is still paid, almost entirely out of the King's shares; but those shares have no concern in the direction—Myddelton having precluded King James from the management, though allowing a person to be present at the company's meetings, to prevent injustice to his royal principal. This

preclusion, and the King's shares being incumbered with the greatest part of the 500*l.* annuity, makes them of less value than Adventurers' shares.

"Many of the Adventurers' shares being, by alienation, divided into fractional parts, the Lord Chancellor Cowper, in 1711, decreed, that the possessors of two or more fractional parts of a share, may jointly depute a person to represent them in the government of the company; whereupon every person so deputed becomes capable of being elected one of the twenty-nine representatives of the whole, who are entrusted with the direction of the company's affairs."

"By the charter, dated June 21, 1619, Sir Hugh Myddelton was appointed the first governor, Robert Bateman, deputy governor, Rowland Backhouse, treasurer, William Lewin, clerk, for life." *

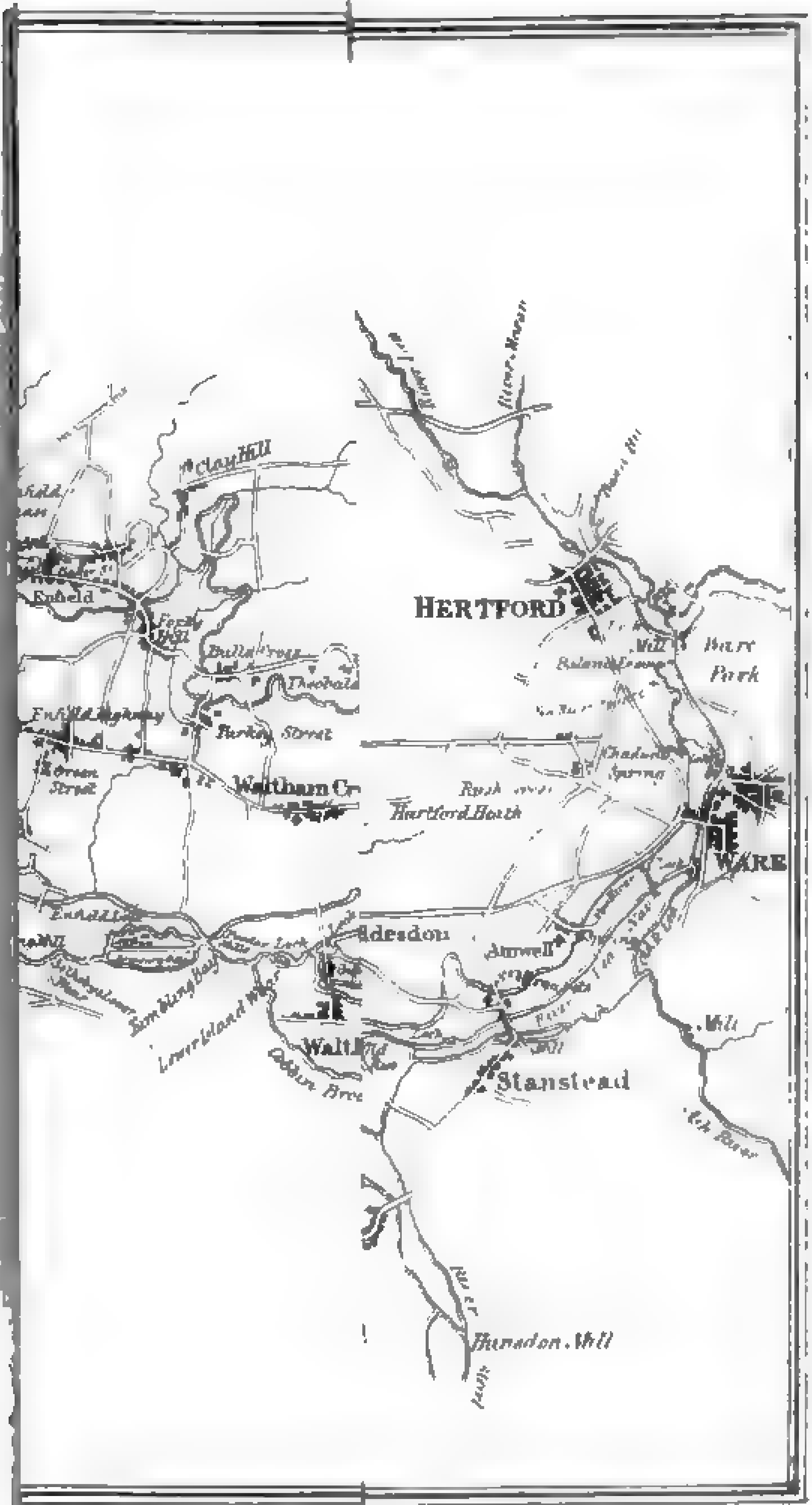
Besides containing various other important provisions, the charter has one which invests the Lord Chancellor with the power of appointing sixteen commissioners to adjust any differences that may occur, respecting the property required for the New River, as well as to make indemnity for any damages that may occasionally be sustained. It also directs that four of these persons shall be chosen from the City of London, and the remaining twelve to consist of four from each of the respective counties of Middlesex, Essex, and Hertford; inasmuch as these are the counties through which the New River has its course. Another clause enjoins that whatever lands may be required for the purposes of the aqueduct, shall not be entered upon till the price shall be finally settled, either by the commissioners or proper arbitrators; and even, when the value has been so decided, if payment be not made in accordance with the agreement, the proprietors of the

* Nelson's *Hist. of Islington.*

lands will be authorized to recover the amount in the courts at Westminster. The company are rendered responsible for all injuries resulting from the breaking of the banks of the river, or other accidents attendant upon their operations.

Commissioners are specially appointed to superintend the execution of the different Acts of Parliament relating to the New River, and its preservation in a proper condition. The persons nominated for this purpose, consist of the Lord Mayor, Aldermen, and Recorder of the City of London; the Members of Parliament for London, and the counties of Middlesex, Essex, and Hertford. On the occasion of making this annual inspection, ten persons, at least, are required to form a *quorum;* and the time fixed for them to assemble and discharge this duty, is the 6th day of August in every year, either at London, or in one of the counties specified, when they are to proceed to the due performance of their functions. The same Commissioners have also the power to scrutinize the obligations of the company, with respect to any loans which they may have obtained, so that they may be repaid with punctuality: and they have authority to ensure that the works for taking the water from the different sources, are carefully preserved at the precise dimensions, as well as in the forms prescribed by the several Acts of Parliament. From this statement it will be obvious, that no ordinary precautions have been adopted, in order to secure and satisfy the public concerning all the chief objects of this very important establishment.

For the purpose of avoiding hills and valleys, the New River has a meandering course, and hence, the various windings render its length considerable, although the springs at its original source, if measured in a direct line from London, are distant only about twenty miles. How-


Clay Hill
Enfield
Forty Hill
Bulls Cross
Theobalds
Enfield Highway
Durham Street
Green Street
Waltham Cr
HERTFORD
Mill
Balsams Leane
Ware Park
Chadwell Spring
Rush
Hartford Heath
WARE
Amwell
Stansted
Waltham Abbey
Enfield Lock
Lower Island Way
Mill
Hunsdon Mill

ever, from an exact measurement made in 1723, by Mr. Henry Mill, the engineer* and surveyor of the New River Company, its extent was ascertained to be thirty-eight miles, three quarters, and sixteen poles. The number of bridges erected over it amount to more than 160; many of them being constructed with bricks, but others are formed either of iron or wood. At different places, beneath its channel, are also nearly sixty culverts, for the currents of different brooks, rivulets, and the passage of land waters after rains. The fall of the New River averages about three inches in a mile; and both its width and depth vary, the former averaging generally eighteen feet, the latter seldom exceeding five. By the original Act for its formation, persons were compelled to sell a quantity of land adequate to the making of it ten feet wide; but in most cases the agreement was made with

* Mr. Henry Mill, when a very young man, at the early part of the last century, became principal engineer to the New River Company, and continued in their service till his death. Endued with a strong mind, which had the advantage of being disciplined by a liberal education, and uniting a taste for the science of hydraulics with great mechanical ingenuity, he therefore possessed, in a high degree, the essential qualifications for properly discharging the duties of his profession. During the long period of his superintending the operations for supplying London with water, his superior knowledge and skill enabled him to devise and introduce various improvements, alike conducive to the public convenience and the interests of the company. Assiduously anxious for the due performance of whatever functions attached to his occupations, the consistent and conscientious tenour of his conduct, invariably secured him the approbation and esteem of his employers and associates. His disposition was amiable and cheerful; his manners mild and courteous; and his vigorous faculties retained their activity, till old age terminated his existence at nearly ninety. He died on the 26th of December, 1770; when he was succeeded in his office by Robert Mylne, Esq., who, some time previous, had been his co-adjutor.—Vide, *Gent. Mag.* 1779.

the owners for a greater portion, so as to obviate any contingent inconveniences; and wherever its course passed through land belonging to the Crown, it was granted without any limitation.

The springs which originally supplied this aqueduct with water, have their site at the villages of Chadwell and Amwell, in Hertfordshire; and when the plan for conveying it to London was first contemplated, its projector probably supposed that they would afford, at all times, abundance for the various wants and other purposes of the inhabitants.

Though no idea was then entertained of any deficiency of water being experienced in the New River, either from the draughts of summer, or any other causes, yet subsequently, even at an early period, such cases actually occurred, and therefore the circumstances suggested the necessity of deriving an additional supply from another source. This exigency impelled the company to obtain a considerable quantity from the river Lea, inasmuch as it flows near to the New River, in a very copious stream. For some years this practice encountered no interruption, but eventually it became a subject of complaint and litigation, which an Act of Parliament terminated about the year 1738. The conditions imposed upon the company were the payment of a sum of money, to be employed in improving the navigation of the Lea; and also a regular continued annuity for the same purpose; so that, on the due fulfilment of these stipulations, they were allowed to take the quantity required for their object. However, it was stipulated that the stream for affording the supply should be confined to certain dimensions, which were regulated by a balance engine and gauge, constructed near to the town of Hertford.

Though wood was the material originally used in the

construction of the *balance engine*, yet the Act of Parliament allowed it to be afterwards continued either with wood, bricks, or stone, provided it always retained the same relative dimensions. The length of its channel was limited to fourteen feet, its width to six feet, and depth to two feet; and that no greater quantity of water might be taken than the Act authorized, the New River company were restrained from having any pen at the guage. For ensuring the strict observance of these stipulations, it was also enjoined that a dam should be constructed and maintained, so that the stream supplying the New River could not exceed the height specified, as the utmost limit allowed for taking water. The guage at present in use is formed with marble; and in 1770, the whole structure, with its appendages, was covered with a building, under the direction of Mr. Robert Mylne, the architect, then engineer to the New River company, to whom is confided the appointment of the person having the care of it.

The company are deemed proprietors of all the water obtained from the different sources, and the Acts of Parliament invest them with authority to prohibit all persons from throwing into their aqueduct, any kind of offensive matter, stones, earth, ordure, dead animals, or animal substances. The washing of wool, hemp, flax, or any unwholesome or improper substances in it is also forbidden; nor can the water be either taken, or interrupted, without their consent; and for any damages done to their works, or dependencies, they can compel the individuals either to restore them to their original condition, or pay an equivalent compensation.

When the several reservoirs at the New River Head, Clerkenwell, were completely filled, being at an elevation of eighty-four feet and a half above the level of high water in the Thames, their capacity was adequate to the

supply of the cisterns in the basement-stories of the houses, through the greater part of the company's whole district, prior to the year 1810. About that period, however, some important domestic conveniences were introduced, which, by requiring a considerable supply to the highest stories, it occasioned the frequent employment of steam engines, to force water to a height sufficient for such purposes. The additional expense of these operations, led to a small increase of the charge for supplying it to the tenants; but among the striking advantages derived from using the steam engines, was that of their affording the means to convey it sixty feet above the level of the highest reservoir, or about 144 feet above the level of the Thames. Besides, this great mechanical power not only ensured a plentiful and regular supply at any altitude; but, at the same time, a larger quantity was allowed, and therefore the tenants materially augmented the dimensions of their cisterns, so that benefits were afforded fully equivalent to the greater cost.

The circumstances which occasioned the use of the steam engine to impel the water to a great elevation, likewise led to the general introduction of iron pipes, and thus the supplying of the high and low services were rendered equally efficient. At present, all the *upper* stories of a house are supplied, if required; but formerly it was the practice to supply water only to cisterns in the basement-story, and hence, arose the distinction between *high* and *low* service. Previous to the adoption of this plan, in 1810, the complaints of a deficiency were numerous and frequent, particularly from houses situate on high ground; but subsequent to that period, such instances have seldom occurred. Indeed, at the present time, the New River company generally convey the most ample quantity to any point over the whole of their dis-

trict, but especially in the direction extending to St. Martin's workhouse, near Charing Cross, a distance of two miles and a quarter from the works, and easterly to the Custom House, near the Tower.

When this establishment afforded the chief supply to the western part of the metropolis, considerable power of machinery for effecting some purposes became essential. At first the use of a windmill was adopted, but from the uncertainty and irregularity of its impelling cause, it was afterwards converted into a horse engine; and this proving inadequate, it was found desirable to employ the more uniform and effective force of a steam engine. Hence, in 1787, the company entered into an agreement with Messrs. Boulton and Watt, for the erection of one of their patent steam engines, of considerable magnitude. It had a cylinder fifty-four inches in diameter, with two pumps, one being twenty-nine inches, and the other twenty inches in diameter. The pressure for its working was about eight pounds on the square inch; and its action was adapted to impel the water sixty feet above the level of their highest reservoir, so that it enabled them to supply water to any required altitude through all the range of their district. Moreover, in order to render the operations more completely effective, another steam engine, of sixty horses' power, was subsequently erected. As both engines have chiefly to effect the high service, and either being adequate to the object, in general only one is employed; but the other is always kept in a state of readiness, to prevent the public from sustaining inconvenience by an interruption of the supply, in case of any accident occurring to the machinery.

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from the saving effected by their improvements, in the expense of coal employed for generating the steam. Hence, to a certain part of every engine, they attached a machine, which registered the number of strokes made by the engine during the time it worked; and the result being carefully entered in a book, enabled them to ascertain, at any time, the quantity of water which the engine had pumped. The register kept of its operations through the years 1787 and 1788, showed that it had pumped 4,490,243 hogsheads, on the average of each year; thus disclosing an important fact, relating to the quantity annually supplied, which previously was not so accurately known. In addition to the power of the steam engine, a large water-wheel was likewise erected, in 1789, which was calculated to elevate a quantity of water sufficient for supplying Islington.

At the commencement of their respective operations for supplying the metropolis, both the London Bridge and New River Works conveyed the water through the different streets by means of wooden pipes, to which leaden pipes, of small diameter, were attached, for conveying it into the houses. The wooden pipes, being generally made of elm, which is a soft and porous kind of timber, occasioned many inconveniences, either from fractures or decay; hence, they proved a source of constant trouble and expense, from a great part of them requiring to be changed every two, three, or four years. At one period, the New River Company alone had different trains of wooden pipes, about 400 miles in extent; but every year, from one cause or other, it became necessary to take up such as were injured or defective, and lay down new ones, amounting to an average of twenty miles, so that, in the course of twenty years, the whole range was entirely renewed. Moreover, the nature of the materials,

as well as their limited magnitude, necessarily confined the bore of wooden pipes to a comparatively small size, varying from three to six or seven, and a few near the reservoirs might be ten or twelve inches; consequently, in order to afford a supply of water to places at a considerable distance from the reservoirs, the use of several lines of such pipes was generally required. In 1810, nine trains were laid, side by side, along one street; and as various causes produced fractures, which permitted the water to escape, when an accident of this kind occurred, it was often very difficult to ascertain the line that contained the broken pipe, or the precise place where the injury was sustained. Hence, it sometimes happened, that a leakage from a single pipe occasioned the examination of a great length of the whole range, so that it occupied the labour of weeks before the defect could be discovered. Besides, during the progress of these operations, the usual supply of water being interrupted, it generally gave rise to serious complaints. Instances have occurred of two or three hundred yards of a street being taken up, and several weeks elapsing before the workmen could discover the leaking place; which, exclusive of the loss of water, and every other consideration, occasioned an expense of 30*l.* or 40*l.* to the company. The quantity of water lost by fractures, &c. was estimated at about one-fourth of the whole that entered them from the reservoirs.

But the most serious inconvenience, as well as calamitous consequences, were occasionally attendant upon wooden pipes; for, when fires happened to take place, owing to their small bore and imperfect condition, not only was a deficiency of water often experienced, but sometimes it was difficult to procure any, though a plentiful supply, on such exigencies, became of the utmost

importance. For nearly two centuries was this inefficient plan pursued; however, eventually, a better system being adopted, it effectually obviated the great disadvantages of the former practice.

Whatever may have been the proximate cause of generally substituting pipes of iron for those of wood, the advantages of the change were strikingly important. Certainly, in some cases, they had previously been employed for conveying water to a very limited extent; but the operations of gas-lighting rendering them indispensable, its extensive introduction probably suggested the general adoption of their use, as conduits for water. The circumstance heretofore mentioned of the improved arrangements in the habitations of the wealthier residents of the metropolis, must also have had some influence in producing the change; for, as different upper rooms contained cisterns, and the height of many of them was considerable, in order to convey water to them, it became essential to use such pipes only as were capable of sustaining great pressure from a lofty reservoir, or that of a powerful steam engine. To either of these the strength of wooden pipes was inadequate; but those of iron could be adapted to bear the application of any force necessary for impelling water to every altitude that such conveniences required.

Although previous to the year 1810, the New River Company had placed in the earth wooden pipes, several hundreds of miles in length; yet, during that period and 1820, the whole were taken up, and others, made of iron, substituted through the entire range of their district. The expense of this alteration amounted to nearly 300,000*l.*, and various large additions have since been made; but great as may be the outlay of capital upon this object, perhaps its expenditure will be adequately compensated

by eventual results. Their strength and durability are very important qualities; for the former renders them less liable to fractures, by very heavy weights passing over them, or other accidental circumstances, so that they will seldom require either change or repair; and consequently, the great expense and trouble, which constantly attended the taking up and replacing the wooden pipes, the re-laying of the pavement, with other concomitant inconveniences, are almost completely obviated. Formerly, these operations cost a very considerable sum annually, exclusive of the vexation and annoyance to the public, by frequently disturbing the pavements in the streets, and the partial interruptions to the flowing of the water into the houses.

Iron pipes were as essentially instrumental in facilitating the supply, as in rendering it more effective than by those of wood. The tenacity of iron allowing their construction of any required dimensions, pipes having a diameter of feet were substituted for those merely of inches; and their strength being also adequate to bear considerable pressure, such were adopted as would sustain a column of water, 300 feet perpendicular. Hence, ranges of these large iron conduits were laid from the elevated reservoirs, some of them commencing with a diameter of three feet and gradually declining in size, according to the distance from the source, or as other circumstances might require; and thus the means were provided both for conveying and retaining, for every purpose, a vast body of water. This great improvement led also to a few of a minor kind, in the practical details of the water-works; such as the construction of the valves, placed at various distances to regulate its flowing, more or less, to different points, and other contrivances for permitting the escape of the air, which might casually

get into the pipes, and if not discharged, would interrupt the current of the water.

It may also be desirable to notice a few other circumstances, relating to the early operations with iron pipes. When first adopted, it was the practice to make a flanche at each end for the purpose of connecting them together by screw bolts and nuts; however, a little experience demonstrated the inconvenience of this mode of constructing them, for the expansion and contraction by the variations of temperature, occasioned their joinings either to become loose and leaky, or the breaking of the pipes. The various injurious effects and disadvantages proceeding from this cause, led to an alteration in their form, which proved an effectual preventative of any defects from the action of heat and cold upon the metal. This important improvement consisted in forming one end of each pipe larger than the other, with a kind of socket, several inches in length, into which the narrow end of the corresponding pipe could be inserted, and the space remaining between them closely filled up with hemp, wadding, and lead, so as to render the joining perfectly water tight.* By adopting this method of connecting the pipes, the changes of temperature has not the effect of breaking them, though occasionally their joinings become imperfect, and require a little repairing to prevent the escape of water.

It is deserving of remark, that when pipes of this material were first introduced, some prejudices existed against their use as conduits for water, from the notion being entertained that iron had a tendency not only to affect the taste of the water, but also to render it hard, as well as objectionable in other respects. Experience, how-

* This improvement is ascribed to Mr. Thomas Simpson, formerly engineer to the Chelsea Water Company.

ever, soon demonstrated that such an opinion had no rational foundation; and, besides the advantages already enumerated, may be mentioned that of its inducing the water companies to introduce the practice of constantly keeping the pipes full of water, so that a plentiful supply may be readily afforded for all occasions, particularly to furnish the means of arresting, or lessening the progress of devastation in cases of fires. But a consideration of no ordinary moment to the public is their tendency to diminish the local rates, by preventing the necessity of disturbing the public pavement so frequently as when wooden pipes were generally employed. Hence, it may be inferred, that they will ultimately prove equally beneficial to the public, and the water companies; for circumstances have occurred satisfactorily demonstrating that when iron pipes are made of adequate strength, and properly laid in the ground, they will continue to perform their functions, and remain sound for upwards of a century.

Formerly, the Water Companies of the metropolis, did not profess to supply higher than the ground floor of any house, and therefore it was not their practice to keep the pipes constantly full of water both day and night, as at present is the case. In fact, prior to the adoption of the effective system now pursued, they found it necessary to be very economical in its distribution; and during the nights, the valve at the upper end of the mains was usually shut, so that when a fire happened, however alarming or extensive it might be, it was necessary to send a messenger to the persons stationed at the New River Head, or some of the other sources, to apprise them of the accident, before a supply of water could be obtained. Watchmen were likewise employed for the particular purpose of being constantly on the look-out for

fires, and as soon as discovered, to convey with the utmost speed information to the respective water-works of the precise places where they had occurred. But the delays usually and unavoidably attendant upon this practice were productive of serious evils, and the destructive element often made dreadful havoc, before any water could be procured to diminish or destroy its power. What a contrast, however, to this inconvenient and ineffective plan, is that now adopted? Whenever, or wherever such calamities occur, a great abundance of water is almost instantly afforded, by means of the simple contrivance of pulling up the plugs connected with the principal mains, and thus the firemen are enabled to supply their engines, without intermission, either to prevent conflagrations from extending their ravages, or effectually to extinguish them.

The above circumstances are so obviously important, as to demonstrate the great benefits derived from the improved operations of the establishments supplying the metropolis with water; and it may be proper to remark, that exclusive of the increase of quantity, as well as the more regular supply for all other purposes, the ample provision for checking the progress of fires has had the effect of materially lessening the charge for insurance. Dispassionately contemplating the large capitals employed and risked, with the constant attention and great expense necessarily required for the superintendence and management of concerns of such magnitude and importance, how striking is the fact, that the average remuneration should amount merely to about one farthing the barrel! How inestimable the advantage to the inhabitants of the metropolis for so trivial a return! Notwithstanding such palpable evidence of its *cheapness*, some persons have been loudly querulous concerning the *high*

and *unconscionable* rate charged for water!* Vituperations have indeed been unsparingly bestowed upon the Water Companies, by different projectors, whose preposterous allegations had neither the sanction of well-attested facts, nor skilful and veracious calculations.

At a former period, a considerable portion of the western part of the metropolis, as well as the City of London, derived a great part of their supply of water from the New River. Circumstances, however, will be narrated in some future pages to explain the causes of forming the districts as at present supplied by the respective water companies, so that each might be confined to a specified portion of the metropolis. The detail will also embrace not only an account of their limits, but the means employed to collect the water, the quantity generally furnished to the inhabitants, as well as other particulars concerning their operations.

The district of the New River Company extends to the west side of Northumberland House, in the Strand, whence its boundary runs along the north side of Cockspur Street; the eastern side of the Haymarket, Windmill Street and Poland Street, in a straight line to Oxford Street; the south side of Oxford Street to Tottenham Court Road and Hampstead Road, till it reaches Camden Town, thence taking the south side of Frog Lane to St. Pancras Workhouse, and eastward of Kentish Town to Highgate. Its eastern boundary is the east side of St. Catharine's Docks, Blue Anchor Court

* The following fact will convey an idea of the mode of charging for a supply of water at an early period. In 1616, Hugh Myddelton granted a lease for twenty-one years to a citizen and his wife, of "a pipe or quill of half an inch bore, for the service of their *yarde* and *kitchine*," by means of "*tooe* of the smallest swan necked cockes," in consideration of the yearly sum of 26*s*. 8*d*. —Nelson's *History of Islington*.

into Rosemary Lane; thence westward along Rosemary Lane to Mansell Street; and along the west side of Mansell Street to Whitechapel; thence along the eastern side of Petticoat Lane to Bishopsgate Street; whence, turning northward, it has its course along the western side of Bishopsgate Street and Shoreditch, to the Drapers' Almshouses; and from there it continues in a straight line to the bridge in the Dalston Road; then taking the western side of Hackney Brook to the high road bridge at Stoke Newington; and in a straight line to Edmonton Church.

So extensive a district, containing about 70,000 houses, of course requires a very large quantity of water for their various purposes. In the year 1827, the works daily supplied, at the height of 144 feet above the level of the Thames, about 1,730,000 imperial gallons, according to the register of the steam-engine by which it was pumped. This, however, formed only an inferior portion of the whole supply of the company, for it amounted, on the average, to about 8,000,000 gallons:—the low service alone requiring the greater part of the water which flowed into the pipes directly from the New River Head, at the height of eighty-four feet above the level of the Thames, without the aid of steam-engines. But if circumstances should require a much larger quantity than has heretofore been furnished for the high service, both steam-engines would be adequate to the raising of 8,820,000 imperial gallons, which would afford abundance to every part of the district. The aggregate annual supply by this establishment, amounts to about 80,000,000 hogsheads; and the whole of the district, east and west of the reservoirs, being below the level of the New River Head, of course facilitates the supply of the mains, which being constantly kept full, are thus

adapted to afford, at all times, a profusion of water, not only for domestic use, but likewise in cases of fires, for watering the streets, and every other purpose.

Notwithstanding the great space over which the operations of this company extend, their conduits are quite adequate to furnish the most ample supply to their tenants; for the pipes branch in every direction from the reservoirs, varying in dimensions, from thirty-six to three inches in diameter. Exclusive of these, a large main, thirty-three inches in diameter, is connected with their steam-engine, on the north bank of the Thames, for the purpose of occasionally procuring water from the river, when emergencies may render it either desirable or indispensable. Recourse to this source, however, is very rarely necessary, nevertheless, the engine is always kept in a state of readiness for use; but it is employed only in cases of the most urgent nature, such as severe frosts, long dry weather, or other circumstances, which occasion either a deficiency, or an interruption in the supply from the New River. This steam-engine is situate between Blackfriars and the Southwark Iron Bridge, at Broken Wharf; and having 100 horse power, with a large pipe extending into the river, from thirty to forty feet beyond the line of low-water, it is capable of affording a supply of about 5000 hogsheads per hour. This provision was prudentially enjoined as one of the conditions of the agreement when the tenants of the London Bridge Works were transferred, in order to ensure to them a proper supply, whatever inconveniences or accidents might occur with regard to other parts of the district.

The company possess four reservoirs, occupying altogether about five acres, at their principal establishment*

* Formerly the business of the company was transacted at a commodious house at the bottom of Dorset Street, Salisbury

in Clerkenwell, designated the New River Head, whence the water is generally conveyed to all the houses of their extensive district. These reservoirs vary in size—one consists of about two acres, but the other three consist of about one acre each, the whole averaging in depth about ten feet, and every one having a connexion with the principal main. Each has two apertures fitted with appropriate cocks, or valves, so that the water can be conveyed from any of them separately, whilst the others may be filling, cleansing, or repairing. Hence, by this convenient arrangement, provision is made for its constant flow into the mains, so as to prevent the service from being interrupted. The highest is that situate on the summit of the hill at Pentonville, comprising one square acre, inclosed by a wall and iron pallisades. The stand pipe for the high service is fixed in this basin, which was constructed chiefly for the supply of Islington. The company have likewise another very elevated reservoir at the upper end of Tottenham Court Road, adapted for the water to be kept *twenty* feet higher than that at the New River Head; its principal object being to afford a plentiful quantity of water, in such emergencies as fires, or if circumstances should require it, to give temporary assistance to the West Middlesex Company; and, for the latter purpose, the mains of both companies have a connexion at the corner of the New Road, and another at the east end of Oxford Street.

Though the various capacious basins above enumerated are stated as the New River Company's receptacles for water, probably the New River itself may be deemed the principal reservoir, being nearly forty miles in length,

Square, where they had a spacious wharf for landing timber, shops for boring pipes, &c., but this is now occupied by the City Gas Works, on a lease from the New River Company.

with a fall of three inches in a mile, and its stream slowly, but constantly flowing from the sources that supply it. However, some disadvantages occasionally attend it in the winter, particularly during heavy falls of snow, when its motion becomes so much retarded, as to prevent the current from being sufficiently copious for its purposes: this circumstance sometimes renders it necessary to procure water from the Thames, by means of the steam-engine at Broken Wharf, so that the tenants may have a plentiful supply.

The means adopted for preserving the water of the New River, free from any offensive matters, are deserving of notice. For this purpose men, denominated *walksmen*, are employed, one of whom is stationed at every four miles, and each has another man under him to assist in guarding the river, keeping the banks in proper condition, and thinning the weeds. At the distance of about every five miles, gratings are placed across the river to stop any vegetable, or other substances that may float on its surface; and as these accumulate, the walksmen remove them. Notwithstanding these precautions, the water is not permitted to flow into the mains, exactly in the same state as it flows from the river into the reservoirs; for, in order to clear it from weeds, or other extraneous substances, which may accidentally get into it, previous to its flowing from the reservoirs to fill the cisterns, it passes through some chambers, across which fine gratings are fitted to intercept them. Every three months these chambers are properly cleaned, so that by various judicious precautions and contrivances, the supply is divested of all apparently objectionable impurity, before it is allowed to go to the houses of the metropolis for the culinary and other purposes of the inhabitants.

The New River being an open aqueduct, has one attendant annoyance, which is the practice of bathing in it by persons contrary to the wishes and rights of the proprietors. To obviate its continuance, but without, at the same time, depriving those who might be desirous of enjoying the pleasure, several years ago the New River Company liberally offered to supply water gratuitously for the purposes of *free baths*, if they were erected for general accommodation, at the public expense; but the offer was unavailing, though the convenience and utility of such an institution must be strikingly evident. The nuisance of public bathing is therefore improperly persisted in, from the company not possessing the power to punish individuals who may commit the offence, except by an action for trespass upon their property; and, as the penalty imposed by the law is *transportation*, considerations of humanity have hitherto prevented the prosecution of the offenders.

Extensively beneficial, and undeniably useful, as the operations of this great establishment have proved to the inhabitants of the populous metropolis of Great Britain, nevertheless, as the greater part of the means employed are invisible, being deposited in the earth, or placed at a distance, their importance has in general been inadequately appreciated. According to the statement made to parliament in 1828, a capital amounting to 1,040,000*l*. had then been expended at different periods to render it completely efficient for its purposes; but since that time large sums have been applied for renewing or extending mains, and effecting various improvements,—others too being still contemplated as opportunities may allow.

In 1830, the New River Company obtained an Act of Parliament for enabling them to purchase fifty acres of land, situate about a mile beyond the church at Stoke

Newington. On this land two capacious reservoirs have been constructed—denominated *Settling Reservoirs*—because their object is the preservation of a large quantity of water, in a state of stillness, in order to become clear before it flows to the New River Head. Their capacity is commensurate with several weeks supply; and a steam-engine of forty-five horses' power is employed to pump it into the New River as occasions may require. During rainy seasons these receptacles will be peculiarly advantageous, by affording an abundance in a pure and transparent state, for all the houses in their district. Another great improvement has recently been effected, consisting of a double row of mains, which are intended to render more complete the supplying of the high service wherever it may be required; and the above important appendages to this establishment, have occasioned an additional expenditure of nearly 100,000*l.*

In Mr. Pennant's *London*, &c., it is stated that the original shares in this concern were 100*l.* each, but without referring to any authority for the assertion. Entick also affirms that the New River cost 500,000*l.*, which sum, divided by the number of shares—seventy-two—gives 6944*l.* and a fraction per share. Probably neither of the statements is correct; and as all the documents relating to it were destroyed by a fire, the fact cannot be ascertained. At present, the magnitude of this establishment surpasses that of every other of its kind; and although the sums of money expended at different times, have been very great, as well as the attention constantly requisite to preserve the works in an efficient condition, nevertheless, the remuneration to the proprietors has, in general, been comparatively small; for notwithstanding the income derived from their operations, the direct and incidental expenses are very large. Besides, it must be evident, that

the original construction, with the successive improvements of the works, have altogether amounted to about 1,250,000*l*. The representations which some persons have formerly given of the profits resulting from them, are palpably erroneous; and perhaps it may not be irrelevant to notice that such a delusive notion was widely propagated by the late Mr. Winsor, with the view of obtaining subscribers to realize his project for gas lighting, in 1805. He affirmed that such "*immense advantages*" would result from his own scheme, that any person, by paying "*a deposit of five pounds*" only, might ensure an annual income, nearly equal to the sum paid upon shares in the New River Company! *

* Though Mr. Winsor certainly excited attention to the subject of gas lighting, no proof exists of his having made any *discovery* or *improvement* relating to it. The merit of first applying coal gas to the purpose of public and private lights, is unquestionably due to Mr. Wm. Murdoch, engineer to Messrs. Boulton and Watt, of Soho, near Birmingham. An attempt to give an accurate detail of the proceedings of both Mr. Murdoch and Mr. Winsor will be found in my *History of the Origin and Progress of Gas Lighting*.

CHAPTER V.

Origin of Chelsea Water Works. Act of Parliament and Charter for incorporating the Company. Different Grants from Government. Amount of Capital: modes of raising it at various periods. Great but unsuccessful exertions. Reserved Fund and its objects. Situation of the Works. Inquiries concerning the methods of Filtering at various places. Construction of Filter-beds to purify all their Water: dimensions, arrangement, mode of operation, and quantity of Water filtered. Materials employed in forming the Filter-beds. Improvement of the Reservoir in the Green Park. District, number of Houses, and quantity of Water supplied.

Experience having demonstrated the great utility of the London Bridge and New River water-works, to those portions of the metropolis over which their supply extended, the inhabitants residing in the western part became desirous of enjoying similar advantages. Hence, encouragement was given to that speculative and enterprising propensity, which has remarkably characterized the people of this country, and it led to the formation of a company for establishing water-works at Chelsea. This took place in the year 1723, when an Act of Parliament was obtained for better supplying water to the City and Liberties of Westminster, and the parts adjacent. The charter granted to the associated proprietors constituted them a corporation, with the designation of the Governor and Company of Chelsea Water Works; and the document bears the date of March 8, 1724. A Royal Warrant, dated 9th of July, 1726, authorized them to convert into reservoirs, as well as to use for their purposes, two ponds situate in St. James's Park; and another Royal

Warrant, with the date of September 9, 1727, allowed them the privilege of making a reservoir in the Walnut Tree Walk, Hyde Park. As the reservoir first constructed in St. James's Park proved too small for its intended object, authority for enlarging its dimensions was obtained, June 9, 1729.

Some advantages seem to have accrued to this establishment at an early period, from its being in the vicinity of several of the royal palaces and parks. An instrument, dated May 31, 1733, allowed the Chelsea Water Works' Company 150*l.* annually for supplying water for the Palace, and the basin in the paddock at Kensington; besides conferring the privilege of their taking the waste water from the great canal or Serpentine River, in Hyde Park. On the 17th of August, 1735, another yearly sum of 50*l.* was also allowed for the supply of the new Treasury, and the houses, offices, and stables, belonging to them. In consequence of a Royal Warrant obtained for the purpose, dated 17th of June, 1736, their reservoir and other works in Hyde Park, were materially enlarged, in order to enable them to afford a supply adequate to the increasing demand for water by the inhabitants.

The capital at first raised by the company, under the authority of their charter, amounted to 40,000*l.*, consisting of 2000 shares of 20*l.* each; but as this was far from being sufficient for its object, Letters Patent were obtained October 11, 1734, to enable them to make an addition of 20,000*l.* to the original sum, thus increasing it to 60,000*l.* To realize the money, 2000 new shares were created, so that by this augmentation the number amounted to 4000. It must also be observed that although authority was obtained, there was some difficulty of realizing money upon the shares, equivalent to their wants, arising from their operations having proved expensive far beyond their

anticipations. This circumstance had occasioned debts to be incurred, for which they had given bonds; and therefore, in order to discharge such obligations, on the 14th of September, 1735, authority was procured for taking subscriptions from members of the corporation only, at any rate or price, under 20*l.* per share, so as to make a provision for defraying the whole original expense of constructing and establishing their water-works.

Though the operations of the company extended over a large and populous district, and the great and obvious utility of such an establishment was evident, yet no dividend accrued to the proprietors during the first thirteen years. The four years 1737, 1738, 1739, and 1740, exhibited an annual average profit of about 1600*l.*; but from that period to the year 1753, the returns were barely adequate to the payment of the current expenses. However, from the latter period to the year 1771, the concern gradually became more profitable, which consequently enabled the proprietors to divide among themselves the average annual sum of 1200*l.* During the subsequent twenty-six years, the whole dividend annually averaged 1600*l.*; from 1797 to 1807, the sum reached 2000*l.*; and from the latter period to 1823, it increased to 2,400*l.*; but from 1823 to 1828, the amount was 2,800*l.* This statement shows, that notwithstanding these water-works had actually been in extensive operation for more than a century, affording great benefit and accommodation to the public, nevertheless, the largest dividend had been only 16*s.* on each share—a trivial pecuniary remuneration, for great and useful exertions, and the employment of a large capital.

It must, however, be stated, that although the proprietors did not receive any dividends for a long period, or such only as were comparatively small, yet during a part

of the time, the whole of the annual income remaining after the payment of all the current charges, was not divided amongst them. The contingent expenses of concerns of this nature, being occasionally very considerable, prudence dictated the propriety of making a reserve out of the annual revenue for such purposes, to prevent the necessity of having recourse to loans or other modes of obtaining money, which it might be difficult to procure at the precise time, when particularly wanted. Besides the original capital of 60,000*l*., other sums were also expended upon the construction of the works; and circumstances subsequently occurred requiring a large additional expenditure, which was amply provided for by the yearly reservation of money constituting the accumulating fund, intended to be applicable for effecting alterations, introducing improvements, or repairing accidents. This provision contributed not only for preserving the whole establishment in proper condition, but in some instances it furnished the means for greatly augmenting its general efficiency; and its utility was clearly demonstrated by the additions and improvements which, at one period, it was employed to effect. In 1810, it had attained the amount of 40,000*l*. three per cent. consols; but during the few subsequent years, different objects occasioned the expenditure of the whole, for the erection of two steam-engines, one of sixty, another of seventy horses' power, with a new engine-house for containing both, besides a main of large iron pipes, which altogether cost about 30,000*l*.

The Chelsea Water Works are situate at the north-east part of Chelsea Reach, on the bank of the river Thames, whence the whole of the water is procured. At this place the company possess several acres of freehold land, well adapted for their purposes; and at a short dis-

tance from the river is erected an engine-house, containing the two steam-engines which are employed to pump the water into the reservoirs. Formerly, many of the houses received their supply of water directly from the river, without its being allowed to stand for the deposition of any extraneous matters that may be mixed with it when in an agitated state; but as this practice occasioned complaints about its condition, it led to the adoption of a great improvement, and the water now passes through the process of filtration, to render it clear before the tenants are supplied. As this operation effectually separates from the water all those substances which occasion its turbid appearance when first drawn from the river, its transparency and taste at the works are equal to that of the finest springs.

To deprive the water of all casual impurities, as well as to clarify it completely, previous to its passing from the reservoirs to the cisterns, became not only desirable but indispensable, to obviate the dissatisfaction at its turbidness, when taken and conveyed directly from the Thames; and the same objections equally apply to that of any other river, especially after rains or floods. During the years 1825 and 1826, Mr. Simpson, the engineer to the Company, made a variety of experiments on the subject of filtration; and the Directors having determined that all the water supplied from the works should be subjected to the process, in January, 1827, they allowed him to make some experiments on a much larger scale than any of his prior attempts; and at the same time urged him to direct his whole attention to the object. In fact, so great was their anxiety to have the plan rendered perfectly effective, that they ordered him to visit Glasgow, and various other places in Scotland, Lancashire, and Lincolnshire, to examine the different methods employed for

filtering water. This injunction induced him to travel about 2,000 miles; and in the course of his peregrination, he had opportunities of inspecting filter-beds which had proved completely efficient for different periods of time, varying from four months to sixteen years. Having, however, contrived the plan of a filter-bed before he left home to proceed on his journey, he directed a model of it to be constructed at Chelsea, of such dimensions that the filtering reservoir should comprise a space that allowed a surface of forty-four feet square at the top of the basin, and with its sloping sides would contain thirty-two feet square of sand, or about 1000 feet altogether.

Soon after Mr. Simpson's return from inspecting the various filter-beds at other places, he made a trial of that which had been constructed by his own direction; and its successful action during more than six weeks, impelled him to make a report of its satisfactory results to the Directors, who accordingly ordered the construction of another of considerable magnitude, and adapted to clarify all the water requisite for supplying the whole of the Company's tenants. This was subsequently constructed, and its operations, which began in January, 1829, have completely realized the most sanguine expectations of its projector.

The filter-bed at Chelsea occupies about one acre; its sides are formed with brick-work, and two reservoirs attached to it consist of about one acre and a half. The water being first pumped into the latter, settles prior to its being permitted to pass into the filter-bed; and as the bottoms of the former are level with the top of the latter, the water flows into it through small pipes without disturbing the sediment. The greater part of the extraneous matter being separated by the deposition of its feculence, whilst standing in the reservoirs, the water

rapidly percolates through the gravel and sand of which the beds are formed. Indeed so completely efficacious is this contrivance, that the quantity of water daily filtered amounts to about 10,000 tons, each consisting of 224 imperial gallons. The cost of constructing these reservoirs altogether was nearly 12,000*l.*; and the expenses annually attending them are estimated at about 1000*l.*

Effective for its object as the first plan of Mr. Simpson had proved, it ought to be stated that in constructing the large filtering bed, he not only introduced some improvements, but also combined with his own contrivance, the advantages which the filtering processes practised at other places had suggested to him. The filtering bed at Chelsea, prior to its being filled with water, has the appearance of several channels parallel to each other, formed by banks, which are broad at the bottom and gradually slope on each side to a point at the top. These banks are composed of three different strata of gravel and sand, carefully laid over tunnels, constructed with bricks, but without the intervention of any mortar. In forming them a stratum of fine gravel is first laid over the brick work; then the same quantity of finer gravel mixed with coarse sand; and lastly, a layer of fine sand. Each layer has a thickness of two feet, consequently the water passes through the whole mass of materials six feet in thickness. The precaution is adopted of well washing the sand and gravel previously to their being employed; and experiments have satisfactorily proved, that the process is most completely effective, when the uppermost stratum of the filter consists of the finest sand. Besides this mode of forming it has another advantage, inasmuch as the feculent matter being chiefly deposited upon the smooth surface of the sand, the accumulated sediment may be easily removed, by carefully scraping it off with an appropriate

instrument. It is remarkable that the matter deposited in the process of filtration scarcely ever penetrates the upper stratum further than the depth of about three inches; but as the greater portion of it rests upon the surface, the removal of the sediment to the thickness of about half an inch, has generally proved quite sufficient to renovate the efficiency of the filter. Circumstances have likewise demonstrated that the inclemency of the seasons does not affect the action of this contrivance, for during severe frosts, and when the ice has been several inches thick, the process of filtration has regularly proceeded without interruption.

The essential and useful object of filtering having thus been effectually attained, the attention of Mr. Simpson was afterwards occupied in adapting the reservoir situate in the Green Park, for the reception of the filtered water. For this purpose it was thoroughly cleansed by removing all the mud and other matters, which had collected in it during several years. Its capaciousness was also augmented by considerably increasing its depth. Among the principal improvements may be enumerated, the paving of the whole bottom with hard bricks, laid on their edges and closely cemented together. It was entirely surrounded by a strong brick wall, five feet six inches high, with a broad stone coping on its top, and iron pallisading three feet three inches in height. The bottom of the reservoir has the form of a curve, commencing from the walls, by an inclination of about two inches in every foot, till it reaches the middle of the basin, when it terminates in a semicircular brick culvert, or open channel, which runs the whole length of the basin, from east to west. This channel is only two feet deep at the east end, where it has a connection with the main well that receives the water, before it passes into the reservoir; but

its gradual slope increases the depth to five feet at the west end of the basin, where it is connected with the tank and main, constructed for discharging the water from the reservoir into the sewer, whenever repairs or other circumstances may require it to be emptied. Thus the means are provided by which the cleansing of the basin may be easily and rapidly accomplished.

The sluices and machinery for the admission of the water into the reservoir, have their situation at its eastern end; and the valves and sluices employed to let off the water, for supplying the houses in different parts of Westminster, are constructed at its south-west angle. The latter are placed in four wells, and have self-acting valves, which permit the water to flow into the mains immediately after the engines at Chelsea have discontinued to work. Besides, by the mode of arranging them, the mains in Westminster and Pimlico, are constantly filled with water both day and night. In order to regulate the column of water, a very ingenious contrivance is placed near to the north eastern angle of the basin; and by the construction of this, Mr. Simpson obviated the necessity of replacing the upright pipe, which formerly stood at its western extremity, and had the appearance of a fountain when the water was entering.

At the four angles of the reservoir, the walls have openings, which communicate with tanks and sluices, for the purpose of affording the means of readily removing any substances, that shall occasionally float on its surface, by sweeping it with a close net, or coarse hair cloth, towards the point to which the wind may be blowing. Another advantage must also be mentioned:—whenever it becomes necessary to cleanse the reservoir, if both ends of the culvert are opened at the same time, as the power of the steam-engines at Chelsea will pump the water up

rapidly, such a velocity may be given to the current through the reservoir as will effectually wash away any sediment that may have been deposited. To prevent any effluvia from passing into the reservoir, during the operation of emptying and cleansing it, a trap conduit is placed adjoining to the well where the water is discharged. All the wells, containing the various contrivances, are fitted with gratings, and covered with York stone landings, having proper man-holes cut in them. They have likewise strong round iron bars, which are ranged horizontally, and secured at each end by being built in the angles of the walls, so as to form safe and convenient ladders under the man-holes, for the workmen to descend and ascend, as occasions may require the examination of the valves, and other parts, connected with the reservoir. Its length is about 220 yards by a width of about thirty-five; but with all its various appurtenances, the space occupied consists of about two acres. From the top of the stone coping to the bottom of the sloping in the basin, its average depth is fourteen feet. Its altitude above high-water mark in the river Thames, is about forty-five feet; and though capable of holding a much larger quantity of water, that employed for serving the public, amounts to about 25,000 tons, which the engines at Chelsea pump into it every four days. The mains connected with it are placed at ten feet below the surface of the water when the basin is full; and hence, it is adapted to afford, in all cases, to the houses in Westminster and Pimlico, a certain, regular, and an abundant supply. The several alterations and improvements in this reservoir have been contrived and introduced by Mr. Simpson, and they have been completed under his superintendence at an expense to the company of about 10,000*l.* But some other improvements have been in contemplation,

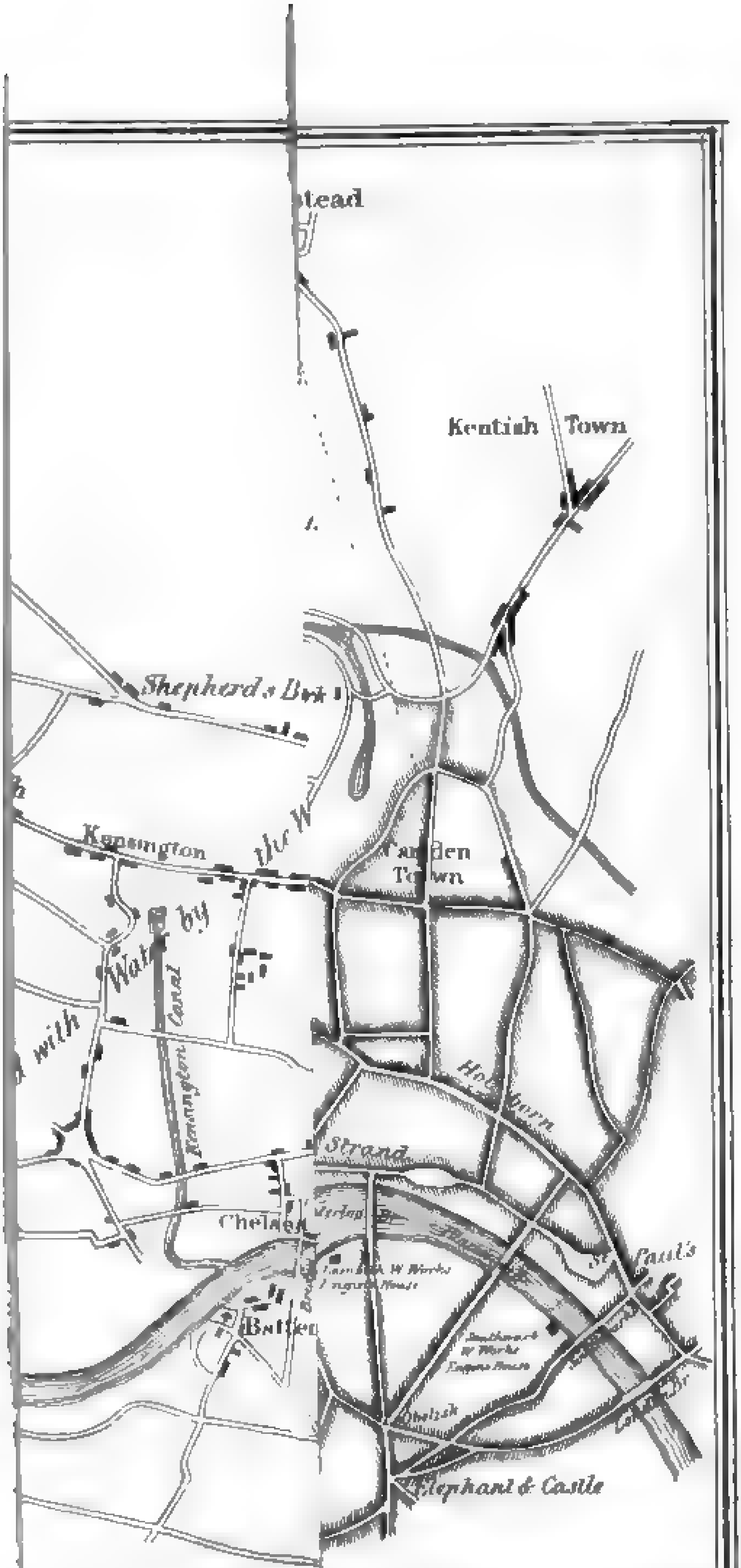
which will tend materially to enhance the efficiency of the establishment :—whether their exertions will be more successful in obtaining greater pecuniary remuneration than heretofore for their capital and services, time alone can evince.

The Chelsea Company supply a district containing all that part of Westminster, which is south and west of a line passing from Northumberland House up St. Martin's Lane to Pall Mall East; both sides of the latter, and the south side of Pall Mall; Cleveland Row; then taking the boundary of the Green Park on St. Jâmes's Street side; the south side of Piccadilly; the boundary of Hyde Park, round by Bayswater and Kensington Palace to the Halfway House, Kensington; from the Halfway House, in a direct line, to the Ball and Horns, at Brompton (not taking the frontage in Old Brompton road); along the Fulham road through Little Chelsea, down to the river. Their mains—some of them very large—are laid through the several squares, streets, roads, and alleys of the district; and the water is conveyed in some places to the altitude of 128 feet above the level of high water in the Thames. The quantity daily conveyed, averages about 2,000,000 imperial gallons; and the number of houses supplied amounts to about 13,000.

CHAPTER VI.

West Middlesex Water-works projected by Mr. Dodd. Act of Parliament to authorize a Company to construct them. [illegible] Amount of Capital: its successive Augmentations. Mr. Nicholson appointed Engineer: his Extension of the Original Plan. Opposition of the Select Vestry of Marylebone. Formation of Reservoir at Kensington, and Erection of Steam Engines. Situation of the Works, and mode of obtaining Water from the Thames. Reservoir at Barrow Hill. Elevations, Dimensions, &c. of different Reservoirs. District, number of Houses, and average supply of Water. Original Scheme for the Grand Junction Water Works, and Mr. Rennie's Operations. Act to incorporate a separate Company to realize the Plan. Adoption of Stone Pipes: their failure. Change to the Regent's Canal for supply of Water, and afterwards to the Thames. Dolphin. Reservoirs and Steam Engine at Paddington. Quantity of Water daily supplied to different Altitudes: limits of District: Number of Houses. Shadwell and Westham Water Works: their inefficiency. East London Water Works: Company for their Purposes incorporated by Act of Parliament. Situation of the Works. Reservoirs, and mode of filling them from the River Lea. Canal and Water Wheel. Flow of the Tides in the Lea. New Canal for procuring a larger supply of Water. Steam Engines. District. Distance and Height of Supply.

Though the continued erection of new houses on the northern side of the Thames, had gradually extended the boundaries of the metropolis; yet, for a long period, the supplying of water to its great population, was confined to the different establishments already described. However, at the beginning of the present century, Mr. Dodd, an engineer, broached the project for constructing the West Middlesex Water-works; and in 1806, an act of



stead
Kentish Town
Shepherd's Bsh
Kensington
Camden Town
Water by
with
Kensington Canal
Holborn
Strand
Chelsea
St Paul's
Batter
Southwark W Works Engine House
Elephant & Castle

parliament was passed to realize his scheme. Its ostensible object was to furnish a supply to the parishes of Hammersmith, Kensington, Paddington, and part of Marylebone. Mr. Dodd proposed to construct the works at Hammersmith, and actually made estimates for that purpose; but after the act was obtained, some circumstance led him to change his views with respect to their situation, and he became desirous to form them at Poole's Creek, near Fulham. To this alteration in the original plan, the proprietors would not consent; and the engineer being pertinacious, altercations ensued, which occasioned his leaving their service in December, 1806, before he had entered upon the execution of any part of the scheme.

At the commencement of 1807, Mr. Nicholson was engaged as engineer to the company, and immediately proceeded in constructing the works, at Hammersmith, where land had been procured for the purpose. Two steam-engines were erected, each having twenty horses' power, and two reservoirs were also excavated, as receptacles for the water obtained from the river. Pipes were laid down through Hammersmith and Kensington, as well as in the vicinity of both places, to the extent of several miles. Land was also purchased at Kensington for another large reservoir; but whilst this was in the progress of executing in 1808, Mr. Nicholson suggested an extension of the pipes, to the north west of Marylebone and Paddington. Commensurate, as the works then in the course of formation might be, with the original views and purposes of the company, yet, they were quite inadequate to such an enlarged scheme of operations as that proposed by their engineer. The suggestion, however, opened to them a prospect of advantages which had not been previously contemplated, and afforded a strong inducement for making an attempt to realize

them. It likewise furnished a very cogent reason for such an augmentation of their capital as should render it equivalent to all the intended objects.

The Act for incorporating the proprietors as a company, authorized them to raise 80,000*l.* by 800 shares of 100*l.* each; but during the first three or four years of their operations, the whole of this money was expended in effecting only a very small part of their plan. They were therefore constrained to obtain an Act in 1810, to empower the raising of a farther sum of 160,000*l.*, thus augmenting the capital to 240,000*l.*, and the number of shares to 2000. After the passing of this Act, 1200 new shares were immediately issued; and at that time, such was the favourable opinion entertained of the concern, that it caused the current price of a share in the market to be at 45*l.* premium, but in the course of a year they gradually sunk to 65*l.* discount.

Notwithstanding the large sum which had been raised by means of the two Acts, it proved to be insufficient to accomplish the object of the company; and therefore another Act was obtained in 1813, to enable them to procure more money. At this period the concern being very low in public estimation, it induced the company to issue a great portion of new shares at 30*l.* each, offering likewise a discount of 2*l.* per share for prompt payment; and by this measure, the number was increased to 7542, and the capital to 340,566*l.* 6*s.* which constituted its whole amount in 1817. Subsequently, however, in 1826, another sum of 37,900*l.* was raised to pay for an additional steam-engine, a reservoir, and some new mains. Flattering as were the representations at first of the probable advantages of the undertaking to the proprietors, they did not receive any dividend from 1807, to March, 1819; and the dividends actually paid

from the latter period to 1828, being trivial, did not amount to the common interest of money. Hence, it will be evident, that, if merely simple interest be added to the capital (and such an addition seems to be equitable), its aggregate amount will attain the sum of 542,248*l*. 14*s*. 3*d*. Indeed, authentic statements proved, that about 380,000*l*. had then been actually expended in the construction and various improvements of the West Middlesex Water-Works.

Whilst the company were laying down mains through those parts of the metropolis, which, according to their own views, the Act of Parliament authorized them to supply, an unexpected obstacle impeded their progress. As the Act mentioned certain parishes and places, as well as *parts adjacent*, this last expression was construed as investing them with the legal power, to carry their works throughout the whole of Paddington and Marylebone, both of which were *adjacent* to the parishes particularly specified. This impression had led them not only to construct the capacious reservoir at Kensington, but likewise to lay down mains from it to London, as well as to make preparations for laying down others in Paddington and a part of Marylebone. In the latter parish, however, an opposition was encountered from the select vestry, who objected to their taking up the pavement. This circumstance occasioned a correspondence between the parties, but the removal of the difficulty was subsequently effected by a clause inserted in the Act obtained by the company in 1810; which, in addition to the parishes of Hammersmith and Kensington, particularly specified "St. James's, Westminster, St. Anne's, Soho, St. Mary-le-Strand, St. Clement, Danes, St. Paul, Covent Garden, Paddington, Marylebone, and such part of the parish of Pancras, as lies south of Fig Lane, St. George, Blooms-

bury, and St. Giles' in the Fields." By this large extension of the scene of their operations, it was computed that a supply of water would be required for 40,000 houses, and the cost of additional works, to realize the purpose, would be 157,000*l.*

As authority was thus obtained for attempting to supply a very extensive and populous district, the company proceeded to augment their means proportionately, in order to ensure success to their efforts. Though, in contemplation of this extension of the original scheme, the large reservoir at Kensington had been formed, yet, as the two small steam-engines erected at Hammersmith, were completely inadequate to such an object, two others were substituted, each having seventy horses' power. This augmentation and alteration in the works, therefore prevented their being effective till the end of the year 1810, when the reservoir at Kensington was completed.

The first rental acquired by the West Middlesex Company was in 1811, amounting only to the small sum of about 335*l.*; but trivial as was the receipt, it is a remarkable fact, that more than 1200 houses, of the district where they undertook to convey water, had not any means of obtaining a regular supply prior to their exertions for affording it. Though the New River and the Chelsea Companies had laid mains to certain points of the district, they extended only to that part of Marylebone, which occupies the angle between Oxford Street and the Edgeware Road; the New River supply extending no farther along the New Road than Quebec Street; the Chelsea Company supplying only as far into Southampton Row as Chapel Street. The annual water rental from 1200 houses had been estimated at 1800*l.*; besides, at that time, about 1000 more houses, some of them very large, with stabling and other appen-

-dages, were then either erecting, or to be speedily built to the eastward of Gloucester Place; and the latter were calculated as likely to produce the annual sum of 3600*l*. The consideration of these circumstances prompted the West Middlesex Company to very strenuous exertions, and during the years 1812, 1813, and 1814, they continued laying down mains with a view to future advantage. Hence, notwithstanding the first anticipations of pecuniary benefit were not realized, yet, from the erection of new buildings and other concurrent causes, the income of the concern has been gradually augmenting, so as to afford the proprietors some reason ultimately to expect a fair remuneration for the large capital expended.

The engines of the West Middlesex Company are situate on the north bank of the Thames, at the upper end of Hammersmith, and about nine miles and a half from London Bridge. The whole of the water is procured from the Thames by conduit pipes of thirty-six inches diameter, extending to a considerable distance into the channel of the river, and the water flows into a capacious well, from which it is pumped by steam-engines. This place is peculiarly favourable for the purpose of taking the water from the river, having a fine gravelly bottom. The company possess about four acres of land, of which a part is occupied by the two small reservoirs, excavated at the commencement of their operations, but having become unnecessary for their original object, they have been disused for many years. The steam-engines at present employed, consist of the two formerly mentioned of seventy horses' power, and another of 105 horses' power, which has been recently completed. In addition to the great reservoir for storing water at Kensington, a very capacious one has been constructed on the summit of Little Primrose Hill (sometimes called

Barrow Hill), and estimated to contain 88,000 hogsheads of water. Its site being 188 feet above the level of the Thames at low water, peculiarly adapts it for supplying the houses surrounding the Regent's Park, which is an object of considerable importance. The cost of this lofty and spacious receptacle, with its various mains and appendages, has amounted to about 60,000*l*.

The height of the reservoir at Kensington is 122 feet above the level of the River Thames, at low water. It has a length of 309 feet, by a width of 123 feet, and a depth of twenty feet. The bottom has the form of an inverted arch, and the whole is lined with bricks. From an estimate of the power of the steam-engines the two of seventy horses' power are capable of daily pumping into it about 3,500,000 imperial gallons; and the same engines, when employed to convey water to the reservoir at Barrow Hill, will deliver 1,750,000 gallons. The large steam-engine of 105 horses' power, is deemed competent to pump into the Kensington basin 2,500,000 imperial gallons, and into that at Barrow Hill 1,750,000 gallons every twenty-four hours. The supply of the greatest portion of the West Middlesex Company's district proceeds from the reservoir at Kensington, but the basin at Barrow Hill being considerably higher, renders it powerfully efficient for all the purposes contemplated in its construction. Besides, with the assistance afforded by a small pump attached to the largest steam-engine, water may be conveyed to a greater altitude than the reservoir at Barrow Hill.

Having ample means for procuring and supplying water, this company's operations are spread over a considerable district. It extends from their works at Hammersmith, in a westerly direction through Chiswick to Turnham Green, and comprises Hammersmith, part of

Fulham, Brompton, and Kensington, passing Westbourne Green to Paddington, and the Kilburn Road, St. John's Wood, the Regent's Park to Mornington Crescent, in the Hampstead Road; then along the western side of Tottenham Court Road, and nearly all the northern side of Oxford Street. But though this is the present boundary of the West Middlesex Company, yet they have the power to supply water beyond the space here defined, because their Acts authorize them to lay down mains in the parishes of Brentford, Battersea, Putney, Richmond, St. James's, Westminster, St. Anne's, Soho, St. Mary-le-Strand, St. Clement Danes, St. Paul, Covent Garden, St. George, Bloomsbury, St. Giles' in the Fields, and so much of St. Pancras as is situate south of Fig Lane. The utmost distance to which the water is conveyed, from the works at Hammersmith, measures about ten miles, and the number of houses supplied amounts to more than 15,000, each of which daily receives, on an average calculation, about 150 gallons of water.

With the view of improving their supply, in 1829, the company purchased, at Barnes, about 110 acres of land, for the purpose of constructing large reservoirs, that the water might settle and become transparent before it was conveyed for domestic use. It was intended that the capacity of these reservoirs should be such as would enable them to supply a large quantity to the Grand Junction, or any other company, if they should require it. If this improvement should be carried into effect, it was estimated that, on an average, the additional cost to each house for pure limpid water, would not amount to more than four or five shillings annually. In consequence of Sir F. Burdett's proposing farther inquiry, the plan has not yet been realized, though probably it is one of

the most eligible projects that has hitherto appeared, to obviate the complaints and objections of the squeamish with respect to the qualities of Thames' water.

Though the great utility of water-works renders them peculiarly deserving of attention, yet probably, the principal reason of so many plans for constructing them appearing almost simultaneously, was, that the magnitude of their cost presented favourable chances for lucrative enterprize to those who devised them. Some of them have, however, proved advantageous to the community, by largely augmenting the quantity supplied for useful purposes and domestic enjoyments. Among the schemes entitled to notice, was that of the Grand Junction Canal Company, who, in 1798, obtained an Act of Parliament to construct *water-works* for supplying the parish of Paddington, and the parishes adjacent; but twelve years elapsed without any attempt being made to effect the object for which it was ostensibly procured.

Procrastinated as the execution of this project had been, eventually the public was apprised of an intention to realize it. An advertisement appeared in the newspapers, announcing the date of the Act, and the authority conferred by it, besides affirming, that "works are now constructing and reservoirs making, under the direction of Mr. Rennie, the engineer, with powers to effect their purpose, *far superior* to any other in the kingdom, and calculated to give to the inhabitants of the parishes and streets supplied, an abundance of pure and excellent soft water, even in the *upper* stories of the houses, or other buildings.—This the proprietors will be enabled to do at a comparatively small expense from the abundance of their sources;—from the height of the ground whence their water will be taken, being so much above the level of the Thames, and it being so con-

tiguous to the parishes of Paddington, Marylebone, and St. George's, Hanover Square, &c., including all the new streets now making and intended to be made. The grand main at present casting is thirty inches in diameter, and will extend down Oxford Street, conveying a body of water unequalled in the metropolis, and which will be an immense advantage in the cases of fire to all the districts through which the pipes will pass. "Great attention being necessary in the execution of an undertaking of such magnitude and public importance, the Grand Junction Canal Company have thought it for the general good, that it should be under a distinct and separate management from their other concerns, which are at present sufficient to occupy any company; they have therefore entered into an agreement with certain gentlemen for the purpose of carrying it into effect; in pursuance of which, and for the more effectual establishment of the undertaking, application will be made to parliament the ensuing session, praying to have the agreement confirmed, and to have the proprietors formed into a distinct company. In the mean time the works are carrying on under the authority and direction of the Grand Junction *Canal* Company, by virtue of the Act of Parliament already made and provided. The fund for carrying the water-works into execution is divided into 3000 shares, of 50*l.* each; 1*l.* per share thereon is already paid into the hands of the treasurer, William Praed, Esq., of Fleet Street. The water, in its present state, has been analyzed, and found excellent for all culinary and domestic purposes; it is also lighter, and contains less foreign matter than the Thames' water; besides, the Grand Junction *Canal* Company are now engaged in making additional reservoirs, and introducing streams of water, which are of the finest quality,

and which will enable them not only to perform their engagement of giving a supply for at least 40,000 houses, but also to meet the demand for water to any extent that may be required. Hence, it is obvious, that the undertaking will be attended with great public benefit, and the proprietors trust they have reason to feel confident of the liberal support of the public."*

The elaborate document from which the above statement is extracted, bears the date of November 15, 1810; but strong as were its pretensions and professions, scarcely one of them could then be realized, and the disappointment proved a fertile source of dissatisfaction and vexation. The agreement mentioned in this announcement, consisted of a lease, conveying to a Mr. Hill and other persons, the power which the Grand Junction *Canal* Company had obtained in 1798; and, in accordance with its purport, an application was made to Parliament in the subsequent session, for an Act specifically to incorporate, as a separate company, the persons who had entered into the engagement referred to. The Act was passed in June, 1811, and it not only confirmed the lease with the power to construct water-works, but likewise authorized the formation of a distinct company for that particular purpose, and the raising of a capital of 300,000*l.* in shares of 50*l.* each. In the first instance, it was determined to create only 3000 shares, which produced 150,000*l.*; but the progressive execution of the undertaking, with some attendant casualties, occasioned the expense to exceed considerably the original estimate; and consequently an additional sum of money became indispensable. In 1814, a loan of 18,314*l.* temporarily supplied several pressing demands,

* Minutes of Evidence to a committee of the House of Commons, 1821, p. 79.

but the money thus obtained being inadequate to the objects of the company, they decided upon raising another portion of the sum specified in their Act.

Plausible as had been the statements of advantages likely to result from the project, hitherto it had merely caused a very large expenditure; and whatever anticipations of future profits might be indulged, the prospect was distant, as well as gloomy. Indeed, apprehensions began to be entertained of the ultimate failure of the scheme, so that the value of shares became greatly depreciated, and those for which the proprietors had paid 50*l.* each, were actually sold for 23*l.* Hence, it was the natural effect of these discouraging circumstances, to produce a very great degree of dismay amongst those who had embarked property in the undertaking.

The company, however, having engaged in an enterprise of such magnitude, perseverance was indispensable, notwithstanding the enormous and appalling expense hitherto incurred, besides that which might still be required for its completion. Though a large sum of money was then wanted to realize their object, yet any attempt to raise the desired amount, by the issue of new shares, at 50*l.* each, seemed to be alike unreasonable and unavailing; consequently, from the marketable price of their shares, at that time, being so low, the idea was suggested of creating additional shares at 25*l.* each, but having the *nominal* value of 50*l.* When, however, this subject was discussed at a general meeting of the proprietors, doubts were entertained whether the Act for incorporating them, authorized such a measure as allowing persons, who should pay 25*l.* only, to receive the same interest as those who had paid 50*l.*; and also, whether the latter class could not eventually compel the former to pay the larger sum, in order to entitle them to

equal interest. The case appearing to be dubious, no person would venture to take any shares, on conditions involving such contingent liabilities; the proprietors, therefore, resolved to apply to Parliament, for an Act to enable them to create shares, which they might sell for any price that could be obtained, according to circumstances. The Act was passed in March, 1816, and invested the company with power to create shares, at the rate of not less than 10*l*., nor exceeding 50*l*. Hence, in June, 1816, it was decided to create 1500 additional shares, at 25*l*. each, but conferring the right to an equal interest with those for which 50*l*. had been previously paid. At the time of issuing these new shares, the persons who were the subscribers to the loan of 1814, had the option of converting the amount of their respective subscriptions into capital, by receiving an equivalent in shares, and the majority acceded to the proposition, when the remaining shares were divided amongst the proprietors, in proportion to the number held by each prior to the division. Every proprietor had also the choice of taking all, or only a part of the shares allotted to him; and those that were refused being afterwards apportioned by another division, the persons then constituting the company, ultimately took the whole at 25*l*. each, although the current price in the market, at that period, was but 23*l*. This measure opportunely realized 37,000*l*., including the part which liquidated the loan of 18,314*l*., contracted prior to the passing of the Act; but in 1826, another sum of 50,000*l*. was added to their capital, in order to effect some improvements, consisting of a new reservoir, and appropriate mains to connect it with their works at Chelsea. Their property was likewise augmented by some land, furnished by the Grand Junction Canal Company, and valued at 27,000*l*.: this is occupied

by their reservoirs, engines, engine houses, &c. at Paddington. Besides the different sums enumerated, may also be added, that under an agreement between the Grand Junction *Water* Company and the Regent's *Canal* Company, the latter expended, on account of works for the use of the former, the sum of 48,169*l.* 0*s.* 3*d.*, so that the whole amount of money invested in the water-works, in 1828, was estimated at 312,669*l.* 0*s.* 3*d.*

Another unfortunate circumstance likewise retarded the progress of this company's operations, and contributed to increase their embarrassments. As Mr. Rennie, the engineer, had expressed a very favourable opinion of the capability of stone pipes, to bear the requisite pressure for conveying water, the company adopted their use. Experience, however, proved the fallacy of his statement; and after considerable expense had been incurred, it became necessary to remove them, and substitute iron pipes, which were deemed far preferable for the purpose, though, at that period, some prejudices were entertained with respect to their affecting the quality of the water. The loss of time occasioned by the injudicious scheme of using stone pipes, was considerable; and the expense incurred by removing them, and substituting others in their place, amounted to nearly 11,000*l.*

The company at first derived their supply of water solely from the Grand Junction Canal, which received it from the rivers Colne and Brent, as well as from a large reservoir, consisting of nearly 100 acres, that was filled by the various streams of the Vale of Ruislip, in the north western part of Middlesex. The water flowing from these sources had been represented as remarkably pure and excellent; but its qualities were found to be inferior to the water of the river Thames, both as regarded softness and transparency, which consequently produced

dissatisfaction and complaints. Indeed, the Directors acknowledged that "such complaints were not without reasonable ground, the quality of the water taken from the canal had disappointed the expectations of the projectors of the original plan—the experience of years having shown that it was impossible to keep out of the canal and the Ruislip reservoir, land drainage; and whilst the Thames was turbid only during the floods of winter, the canal was frequently so. The waters of the Brent were discovered to be so foul, that it was necessary to prevent their entering the canal; and a like necessity caused the waters of the Ruislip reservoir to be conducted by a tunnel under the canal—the supply from both these sources proving unfit for the use of the water-works."* This sombre statement exhibits a very striking contrast to the fascinating representations given to the public at the announcement of the concern; but whether it be correct or otherwise, a change in the source of obtaining the water afterwards took place, and circumstances seemed to render it indispensable.

In the progressive extension of the company's operations, at a subsequent period, the demands upon them for water increased to such an extent, that the canal company experienced not only great inconvenience, but actual difficulty, in supplying the quantity which the wants of the former required. Hence, on the formation of the Regent's Canal, an arrangement was made between the several parties, for transferring to the Regent's Canal Company, the legal authority to furnish an adequate quantity of water, for the use of the Grand Junction Water Company. But another circumstance had some influence at the time of making this agreement, for it was presumed, that deriving the water from a different source,

* Minutes of Evidence.

would tend to obviate the complaints about its quality, as well as afford the means of a more abundant supply. In this instance, however, the expectations indulged were but partially realized; and the quantity supplied by the Regent's Canal ultimately proved quite disproportioned to the constantly increasing demands of the public. Complaints also frequently occurred, both with regard to the quality of the water, and a deficiency in the quantity supplied, which finally occasioned the Grand Junction Water Company to determine upon procuring it, for their purposes, solely from the river Thames. From this exuberant source alone they have obtained it ever since September, 1820; and, notwithstanding the confident asseverations of a few medical practitioners, and the misrepresentations of interested and not very enlightened schemers, probably better, or more salubrious, water cannot be found for all the necessary and useful purposes of human life.

When the company had decided to obtain water from the Thames, they purchased about four acres of land at Chelsea, on the bank of the river, in order to construct appropriate works for effecting their object; and the site is between the Royal Hospital and the Chelsea Water Works. At this place two steam-engines were erected, each having 100 horses' power; and the method adopted to procure the water is similar to that at the West Middlesex Works, by a means of a conduit pipe laid many yards into the bed of the river, with its extremity terminating in a small inclosed building, denominated—*a dolphin*. The top of the pipe, at this point, is nine inches below the surface of the water, at the lowest state of the tide, and the pipe has an inclination of six inches towards the engine well, which is constructed much lower than the conduit pipe. The steam-engines pump all the

water from this place to reservoirs at Paddington; and since the year 1827, great improvements have been made in the mains, and some other parts of the works, at a very large expense.

For the reception and preparation of the water, the company have three spacious basins, at Paddington, which are respectively called the North, the South, and the Engine reservoirs. The one designated the *North*, is estimated to contain 153,456 hogsheads of water, having an altitude of ninety-one feet ten inches above the high water mark of the river Thames: that called the *South*, has the like relative altitude of eighty-five feet ten inches, and will contain 139,921 hogsheads; and the *Engine reservoir* will hold 65,063 hogsheads; but it is formed fifteen feet lower than the latter, its height above high water being only seventy feet ten inches. The North and South reservoirs being constructed at different elevations, as well as in situations higher than the Engine reservoir, their respective position affords the advantage of allowing the water to flow from the higher to the lower, whenever occasions may require it, without disturbing the sediment, after the water has become clear.

Though all the water supplied by these works be thus obtained from the Thames, yet it remains for some time in the reservoirs, in order to settle and deposit its feculence, before it is allowed to flow into the mains for domestic use. The quantity daily supplied averages nearly 3,000,000 of imperial gallons, and about two-thirds of this amount are delivered to heights varying from 90 to 110 feet; but the remaining one-third consists of the highest service, which is from 110 to 150 feet above the level of high water in the river. The high service is principally effected by means of a steam-engine of seventy horses' power, erected at Paddington,

and having a stand pipe rising sixty-one feet two inches above the South reservoir. Thus the elevated site of the reservoirs, and the power of the engine, facilitate the conveyance of water to any altitude that circumstances may render either desirable or necessary. The greater part of what is termed the low service, being much below the level of the reservoirs, the water flows to the cisterns directly from the mains, without employing the steam-engine; and the most distant point of their supply is about two miles from the reservoirs, which are at the distance of nearly two miles and a half from the works at Chelsea. The quantity of water which each house daily receives, has been stated to average more than 300 gallons, consequently allowing a large portion for waste.

The district over which the supply of the Grand Junction Company extends is comparatively small, and occupies a narrow space from their works at Paddington to a point near to the southern extremity of the Hay-market, whence it is bounded by a line running in a northerly direction up to Oxford Street, and it includes the intervening space between that line and the eastern sides of Hyde Park and the Green Park. It also comprises a number of streets from the Uxbridge Road to Seymour Place, near the New Road. But though its boundaries be so limited, it contains about 8,000 houses, many of which are large; and as one-fourth of the number have also the highest service, consequently a proportionate rate is paid for the convenience.

When the high service was first undertaken, the great trouble and expense to effect it, beyond the ordinary means of supplying, seem not to have been calculated; but as the additional cost was considerable, it became an incumbent duty on the part of the Water Companies, to increase the rate, so that the remuneration might be

adequate to the advantage afforded. Just and reasonable, however, as the attempt must appear to the reflecting and dispassionate, it involved the Grand Junction Company in a very serious contention with many of their tenants, several of whom engaged in a plan for opposing them. This circumstance temporarily affected their prosperity; and if the project had succeeded, it would have had the fatal effect of greatly depreciating the value of their property, with the probability of rendering their works almost useless.

Though the Water Companies ventured to advance their rates, it was merely to indemnify themselves for the extraordinary practice of plentifully supplying water for domestic use, to the very tops of the houses; and to accomplish this important object, they had expended money to an enormous amount, yet the utmost charge ever made for this great convenience, including all others, amounted only to about *one farthing* a barrel! Besides, this fact is entitled to very particular attention, because, small as was the sum, it was considered *extravagant* and *unconscionable*, by an association of persons, the most active and conspicuous of whom either possessed easy lucrative places under the government, or belonged to the medical profession, than whom none generally receive more ample or liberal remuneration for services, sometimes very unimportant, and too frequently ineffective. The circumstances, however, led to a parliamentary investigation, the particulars of which will be narrated in some subsequent passages; and the whole tenour of the evidence adduced will clearly show, that the complaints were either captiously frivolous, or palpably unjust, though they had the effect of injuring and retarding the prosperity of the Water Companies. Indeed, its chief object seemed to be that of saving a few pounds annually

to a very small number of individuals, having no views of conferring a benefit upon the community, though their conduct produced great uneasiness, and occasioned considerable expense, both to the Water Companies and the public. In short, the end aimed at could not but appear insignificant, in the estimation of every liberal mind, and the means employed to attain it, at once ungenerous and and illaudable.

The numerous inhabitants of that portion of the metropolis which is situate to the north of the river Thames, and east of the City of London, formerly depended for a supply of water upon the New River, Shadwell, and Westham Water Works; but the quantity afforded by these different establishments was partial, and generally inadequate to their various wants. Indeed, in some parts of this extensive and populous district, so great was the deficiency, that many persons were constrained to procure it by any casual means, which circumstances placed within their power.

The works at Shadwell originated with Thomas Neale, Esq., the lessee of estates in the parish, belonging to the Dean of St. Paul's; and at first the establishment merely employed one four-horse engine, but in the year 1679, on the works being rebuilt and enlarged, two such engines were erected. For the security as well as the improvement of his property, in 1687, Mr. Neale applied for a charter, and at that period he divided the concern into thirty-six shares, which enabled him to realize a considerable sum of money. A few years afterwards, the shareholders were constituted a corporation, by letters patent, dated 1691. The horse engines were employed to raise water till 1750, when it was effected by the use of a steam-engine, constructed upon the old plan; however, its power proved inadequate for its purpose, and occasioned serious losses to the proprietors. Not-

withstanding the palpable inefficiency of the machinery for its intended object, no attempt was made to augment the means of supply till 1774, when the company purchased an improved steam-engine from Messrs. Boulton and Watt. Its power was calculated to raise upwards of 54,000 gallons of water every hour, and consequently at once increased their ability to supply, as well as materially diminished the expense of their operations. The Shadwell Water Works supplied a district, containing about 8,000 houses and other buildings, comprised in the space extending from the Tower of London to Limehouse Bridge, and from Whitechapel to the river Thames.

The lower part of Whitechapel, Stepney, and Bethnal Green, as well as the adjoining villages of Bow, Stratford, and Bromley, were supplied by the water-works at West Ham. This establishment began its operations in 1745, and had both a steam-engine, and one that moved by water, with a reservoir at Mile End. The property consisted of four shares only; and in 1807, the works, as well as those situated at Shadwell, were sold to the London Dock Company.

Constantly increasing as was the population of this extensive district, during a long period, the means of supplying water for their domestic and other purposes, continued to be nearly stationary. Hence, a large portion of the inhabitants were subjected to great inconveniences, till a remedy was provided, and the deficiency obviated, by some enterprising individuals engaging in a project to establish water-works upon such an extensive scale, as should be competent to convey abundance to every part of the various parishes. In the course of the year 1807, they were incorporated by an Act of Parliament, under the designation of the East London Water Works' Company, with authority to raise the sum of 100,000*l.* for effecting their purposes, in 1,000 shares, of 100*l.* each.

This large capital, however, was not only soon expended, but proved so far insufficient for attaining the object contemplated, that in the subsequent year, 1808, another Act became indispensable, to empower them to raise the farther sum of 280,000*l.* by creating 2800 additional shares; thus increasing the capital to 380,000*l.*, and the number of shares to 3800. The Act also invested the company with authority to purchase from the London Dock Company, the water-works at Shadwell and Westham, which they consequently accomplished; but to obtain the possession of both establishments, and for their subsequent improvement, required the expenditure of 180,000*l.* Whether it be an insurmountable difficulty to form a statement which, in the first instance, shall approximate to the real cost of a great undertaking, is a problem that yet remains to be solved; for, in this case, nearly four times the amount of the original estimate was required to carry on the operations, within a short period from their commencement.

The company having chosen Old Ford as the most eligible place for their purposes, obtained about thirty acres of land on the banks of the river Lea, and well adapted for the situation of works, capable of affording a plentiful supply to all the inhabitants of the large district intended to be the scene of their operations. For the reception of the water four reservoirs were constructed, which altogether occupy about eleven acres. The two largest are situate on the east side of the Lea, excavated so that their bottoms are on a level with the bed of the river. The depth of two of them is about ten feet; the other two about fifteen feet six inches; and the whole are inclosed with brick-work. The latter are situate on the west side of the river, being also sunk five feet six inches deeper than the others, that their bottoms might be

fifteen feet below the surface of the water, at medium tide, and so as to have their surface level between the spring and neap tides. The water flows into these reservoirs, from the river Lea, through six channels, having altogether a width of forty-two feet, but differing in depth, two of them being four feet six inches, three others four feet, and one three feet six inches, deep. During spring tides the water runs into them for about four hours, but during the neap tides, only about two hours; and when the whole are filled, they contain a sufficient quantity for a week's supply.

When the reservoirs are quite full the water is usually permitted to remain in them for two or three days, that it may deposit its feculence and become clear; besides, the whole are so constructed that the contents of any one may be drawn off separately, by means of the different tunnels which form the connection between them. The mud that accumulates can be readily removed, because their construction admits of the water being let out to within eighteen inches of the bottom, at the lowest neap tides; and any that may remain can be pumped out by the engines: thus, whenever cleansing becomes necessary, it is effected without any difficulty. An aqueduct, constructed under the river Lea, forms a communication with each of the reservoirs; and the company have likewise a reservoir at Mile End, near to the Regent's Canal Bridge. Its site is about sixty feet above the level of the river Lea, and it is sufficiently capacious for supplying 6000 houses. In addition to the various spacious receptacles already enumerated, there are means to form another, if it should be required, by shutting up the canal, called the Water Works' River, at Stratford; and the length of this is about a mile, with a width of from thirty to forty feet. Connected with this canal are two iron mains, one

of them being twelve inches, and the other nine inches, in diameter; besides, the operations have the assistance of a breast-shot water-wheel, equal to twenty horses' power.

The distance of the principal works from the Thames is rather more than three miles; but the Act of Parliament to incorporate the company, enjoined that the whole of their supply of water should be taken from the river Lea, when the water flows up during the tides, and the mills have discontinued to work. Accordingly, as the sluices belonging to the mills, situate upon the banks of the Lea, may be opened more or less, the time varies at which the tide reaches the reservoirs at Old Ford; but in general it is near an hour later than in the channel of the Thames; and at the time of low water, the level surface of the latter is about thirteen feet lower than that of the river Lea. The perpendicular rise of the tide in the Thames, at the mouth of the Lea, is eighteen feet; whilst, at the water-works, the rise is only five feet. This circumstance occasions the water of the Lea to be pent back and accumulate, during the rising of the tide in the Thames; so that four hours elapse before it begins to flow up to the reservoirs, when the whole mass of water collected in the Lea, between the Thames and the reservoirs, passes the site of the water-works. The water runs down the Lea, towards the Thames, at the rate of about two miles an hour, but its return does not average the rate of one mile an hour, and it scarcely ever flows up three hours; hence, this alternate flowing of the water upwards and downwards, occasions the reservoirs to be filled by that of the river Lea only. Although the tide flows up the Thames for about six hours, its current in the Lea is not nearly so long; sometimes it is not more than half an hour, and, during floods, it does not

1820, become the property of J. Edwards, Esq.; in 1822, he purchased, from the New River Company, the works on the south side of London Bridge, and combined both concerns by the designation of the Southwark Water Works. The whole being thus possessed by an opulent individual, two steam-engines were erected, one of thirty-six horses' power, and another of eighteen. Prior to this period the supply of water had always been conveyed through wooden pipes, but these were gradually taken up and iron pipes of larger dimensions substituted, varying in their diameter, from three to sixteen inches. Another important alteration consisted in the mode of taking the water from the Thames; and instead of obtaining it near to the shore, a large iron main was carried along the bottom to the middle of the river, where it is gravelly—the mouth of the conduit for conveying it to the wells of the steam-engines being also covered with an iron semi-sphere, perforated with a great number of small holes. This contrivance is placed eight feet below the low-water mark, and the interior end of the conduit, adjoining the well, has a vessel constructed with wire for intercepting any substances that may pass through the holes of the semi-sphere: the water also runs through another similar contrivance in its passage to the pipes for supplying the inhabitants. The establishment has not any reservoir, but in order to obtain a height of pressure, the water is pumped into a cistern constructed at the top of a tower, nearly sixty feet high, and adapted to contain from 300 to 400 barrels of water, whence it flows to the houses below its level, some receiving it as high as to ty-two feet. The two engines are competent to raise 4,000,000 imperial gallons in the course of every twenty-four hours. In the original construction and subsequent improvement of these works, more than 70,000*l.* have been expended

at different times, and they supply about 7000 houses daily with about 1,500,000 gallons of water. The high service extends only to about 800 houses in the district, which comprises a space, in various directions, two miles from the engines; and the great Hospitals are supplied from this source.

Various, ample, and effective as were the water-works on the north side of the Thames, nevertheless, the inhabitants of Southwark and its environs, principally depended upon the above two establishments for a very long period. Defective as were the means, and incommensurate with the wants of the great and continually increasing population, the object of supplying them with water seems to have afforded but little temptation to the speculative part of the community. Eventually, however, a number of individuals associated for the purpose of forming the Lambeth Water Works. They commenced their operations with a small capital; but by careful management, and avoiding a large expenditure at the commencement, a remarkable degree of success attended their enterprise. At first each proprietor gave his services gratuitously: one acted as secretary, another as engineer, others as managers, collectors, &c. This practice continued for many years, during which, instead of dividing the profits, they were devoted to the improvement of the works; and the pecuniary result affords the amplest evidence of their economical proceedings. But although this may be one cause of their prosperity, it must be acknowledged that others also concurred, and among the principal perhaps may be named, the extensive and populous district of which they have long had the almost exclusive supply, at an inconsiderable cost, inasmuch their works occupied only a small space on the bank of the Thames. Besides, they avoided to incur any expense in constructing large

reservoirs, but conveyed the water directly from the river, so that their disbursements were small, in a comparison with most of the other Water Companies. Hence, they derived a greater pecuniary benefit from their operations, in proportion to their extent, because the rates were nearly the same.

The proprietors of the Lambeth works were incorporated as a company in the year 1785, by an "Act of Parliament for Supplying the Parish of Lambeth and parts adjacent, in the county of Surrey with Water;" but the Act restrained them from laying down pipes for conveying water into any of the streets which at that time were paved, and situate in the parishes of Saint George and Saint Saviour's, Southwark. Their property is divided into thirty-two shares, on each of which 185*l*. was originally paid; but though the Act for their incorporation defined the number of shares, it did not fix the precise sum to be advanced upon each, and therefore the subscription was extended as necessity or convenience required. However, the nominal amount of a share was understood to be 300*l*.; and if this sum had been actually paid upon the whole number, the capital would then have amounted to 9600*l*.; but of this only 5920*l*. was really advanced by the original shareholders.

Though the latter constituted the total amount of the first outlay upon the works, yet their progressive extension has since required the expenditure of large sums, which have been provided by the occasional application of the whole of the nett income to the purpose, instead of paying dividends to the proprietors, or calling upon them for additional subscriptions to augment the capital. Consequently, during sixteen years of the time that has elapsed, from the commencement of the undertaking, no dividends have been paid; and the

periods of their being made have generally been irregular. Sometimes the proprietors did not receive any dividend for several successive years; then for two or three years a dividend would be regularly made, but afterwards it was again suspended: so that by thus occasionally expending the income instead of dividing it, according to a statement delivered to the House of Commons, in 1828, they had actually expended upon the works the large sum of 130,084*l.* 5*s.* 5*d.*—nearly the whole of which had been derived from the profits of the concern, exclusive of the dividends paid at different times, and all other incidental expenses. Perhaps this has been the most lucrative of any Water Company ever established; for, according to a statement made to a committee of the House of Commons, in February, 1834, the thirty-two shareholders had received annual dividends, during sixteen years: *viz.* from 1818 to 1833 inclusive, the large sum of 66,400*l.*—the lowest being 50*l.* and the highest 250*l.*,—several of the payments being 100*l.*, 120*l.*, and 150*l.* The estimated value of each original share was also stated to be 3000*l.*

The Lambeth works are situate in the Belvidere Road, at a short distance from Waterloo Bridge, and nearly opposite to Hungerford Market. Until a recent period, the establishment consisted of two steam-engines, one of eighty horses' power, and another of thirty-six, which impelled the water to the cisterns of the tenants,—the highest service being then only forty-two feet above high water mark. The greatest distance of the supply from the works was about three miles; and to afford assistance in cases of fires, a large cistern, containing more than 400 barrels, was constantly kept full. Besides, a man particularly attended to such emergencies, so that when

a fire occurred, he immediately turned the cock to fill the mains, whilst the attendant at the engine set it to work.

Though such was formerly the practice and state of the works, in 1832, some important improvements were introduced, by the erection of a new steam-engine of 110 horses' power, and also the construction of a reservoir on Brixton Hill, at an altitude of 150 feet above high water mark. Previously to this period, the conduit of three feet diameter for obtaining water, extended only about 300 feet into the river, and had a dolphin at its extremity; but at the time of erecting the engine the conduit was lengthened by the addition of nearly 100 feet, terminating with a grating that rests upon a gravelly bank, six feet below low water mark. From this place the water is pumped to the elevated reservoir at Brixton, which facilitates the high service, as well as renders the general supply more regular. The execution of this receptacle allows all the mains to be constantly kept full, so as to afford prompt and ample assistance when fires occur, besides an increase of quantity to each house. Since the construction of the above reservoir, two others have likewise been formed, with different elevations on Brixton Rise, the intention of one of them being to filter the water. The surface of both the latter receptacles consists of about three acres, with an average depth of fifteen feet, and adapted to contain nine days supply of their whole district. To provide for these and other improvements, the company obtained an Act of Parliament in 1834, to enable them to augment their capital 130,000*l*. by shares of 100*l*. each.

The Lambeth Company's district comprises about 16,000 houses, formerly divided into two portions, to each of which the water was supplied three times a week, by

alternately working one of the engines—the largest being employed from seven to ten hours a day—the smallest a greater number of hours, but both never worked at the same time. The highest point to which their power was applied to impel water being only sixty feet above the level of the Thames, high service did not form an object of supply; and about 1,500,000 imperial gallons were then daily conveyed to the cisterns of the tenants. Their pipes are laid down over a space extending along the banks of the Thames to the back of Vauxhall, thence turning towards Kennington Common, Walworth Common, Kent Road, Bermondsey New Road, and to Bankside. The principal mains are iron, eighteen, twelve, ten, and nine inches diameter; though till lately a considerable part of the service pipes were wood; but iron pipes have been gradually substituting for them; and this operation will continue till the whole consist of the latter material.

When the water was originally obtained at a greater distance from the middle of the stream, and conveyed to the houses in the same state as it came from the river, dissatisfaction with its quality often occasioned serious complaints. Indeed such might naturally be expected to occur from the situation whence the supply was procured, because it was particularly liable to be rendered turbid by mud and other matters being mixed with it, from the constant motions of barges and boats, as well as the ebbing and flowing of the tides. Though turbid water be offensive to the sight, experience has satisfactorily proved that it is not injurious to health; nevertheless, perfectly clean and limpid water being preferable for beverage, and indispensable for washing and various other domestic purposes, all the Water Companies will probably adopt some decisive means for purifying and

rendering it thoroughly clear, so as to convey it in that condition to the inhabitants. The period may not be far distant, when the residents of this great and populous metropolis will, perhaps, have the advantage of generally receiving *filtered water* for their chief domestic uses, successful experiments having demonstrated its practicability. Besides the increasing taste for cleanliness and other circumstances, require that improvements shall adapt its condition to the wants and habitudes of the age, and therefore its supply should be as pure and transparent as its nature will admit.

Although three establishments had long existed in the southern portion of the metropolis, for supplying water to its inhabitants, besides their having the use of many private pumps, yet the population had so largely increased as to encourage the attempt to construct another water work. Circumstances also concurred to render such an undertaking desirable; for at that time both the Southwark and Lambeth works conveyed the water directly from the Thames to the houses, without the intervention of any reservoir, where it might remain for some time to deposit its sediment. Hence, it was frequently in such a turbid, or muddy state, as to be quite unfit for various culinary and domestic purposes. Moreover, the water procured from the pumps being generally hard, as well as having other objectionable qualities, it could not be used for washing, so that a supply of soft, clear, and salubrious water, seemed to be not only desirable, but to a great extent indispensable.

With the view of effecting an object so important to the numerous residents of this district, in the year 1805, some persons united to realize the scheme for constructing the South London Water Works; and by an Act of Parliament passed in July of the same year, they were

incorporated as a company, with authority to form a capital for attaining their object, amounting to 80,000*l* in 800 shares of 100*l*. each. In the first instance 90*l*. only was paid upon each share, but exclusive of the money so raised, instead of paying annual dividends to the shareholders, the whole surplus of the income that exceeded the discharge of the necessary current expenses, was, for several years, applied to the improvement and extension of the works. Though by pursuing this plan the capital employed became considerably augmented, still it proved inadequate to the full accomplishment of its object; and therefore another Act was obtained in June, 1813, for empowering the company to raise a further sum of 80,000*l*. This authority led to the creation of 150 additional shares of 100*l*. each; but different causes afterwards involved them in pecuniary difficulties, and their exigencies impelled them, in 1823, to borrow Exchequer Bills to the amount of 7000*l*.

At the time this loan was obtained, the nominal amount of the company's capital was stated to be 95,000*l*.; since that period the creation of fifty more shares has increased it to 100,000*l*.; but according to the statement made to Parliament in 1828, the money actually expended upon the works, had then amounted to the sum of 184,394*l*. 2*s*. 7*d*. Recently various improvements have occasioned the expenditure of another large sum, but great as may have been the whole cost to the proprietors, and beneficial as their exertions have proved to the inhabitants of the district, by affording a plentiful supply of good water, nevertheless, from the time of their incorporation in 1805 to 1834, they have obtained the very trivial pecuniary benefit of only the small sum of 24*l*. in dividends.

The operations of this company commenced inauspi-

ciously for their interests, from their first adopting the method of conveying water by means of wooden pipes; but as in similar cases their inefficiency for the object soon became evident, and necessity therefore impelled their removal to substitute strong iron pipes in their place. Thus a great loss was sustained, and considerable additional expense incurred, neither of which had been contemplated in their original estimates. However, the alteration became indispensable, because the use of large iron mains would alone enable them to afford a proper and abundant supply of water, wherever it might be wanted in the district which they had undertaken to serve.

This establishment has its principal works on the south side of Kennington Lane, formerly Kennington Common, near to Vauxhall. At first, the use of two small steam-engines was adopted, but the united powers of both proved so incompetent to effect their intended purpose, that it became necessary to remove them in 1822, when one engine of 45 horses' power was erected, which forced the water to an altitude of sixty-five feet above the level of the reservoirs. Since that period another steam-engine, of twenty horses' power, with a pump of sixteen inches diameter, has also been erected at Cumberland Gardens, adjoining Vauxhall Bridge, for the purpose of impelling water from the Thames to the reservoir in Kennington Lane. The well of the latter engine receives it by means of an iron tunnel, having a diameter of forty-two inches, and extending into the river, as far as the third arch of Vauxhall Bridge, where it terminates at the depth of six feet below the lowest water mark. Though a part of the water was formerly conveyed to the works by this contrivance, yet some portion of it passed to them up the channel of the Vauxhall Creek; but this practice has

been discontinued for a considerable time. Besides, to prevent any communication with this channel, during the year 1832, the company laid down a range of large iron pipes, *four* feet in diameter, for the purpose of connecting the river Thames with their several reservoirs; and probably this conduit exceeds in dimensions every other hitherto employed for a similar purpose, in the metropolis. In some parts of the range, they are also placed twenty-four feet below the surface of the ground; and their average depth is about twelve. It is also an important circumstance in favour of deriving it from this source, that the water of the Thames, near to Vauxhall Bridge, is generally both pure and clear; besides the abundance thence obtained enables the company to afford an ample supply, wherever their operations extend. Hence, if the demand in their district were thrice the quantity at present supplied, the works would be found adequate for satisfying such an additional claim.

In Kennington Lane this company possess about five acres of land, where they have two circular reservoirs, each having a diameter of about 175 feet. As one of these basins has a more elevated bank than the other, their respective depths vary—the higher being fifteen and a half feet, and the lower twelve feet deep:—both are lined with bricks, the bottoms gradually sloping from the circumference to the centre, so that any feculent matter, subsiding from the water, may tend to the lowest point. During the spring tides, the water flows from the Thames into these receptacles as high as nine feet; but by the assistance of the steam-engine, they are completely filled to the top as occasions may require. When it is quite full, the deepest alone contains about 2,000,000 gallons of water, a quantity more than sufficient for the daily supply of their district.

Among the recent improvements of the works must be enumerated, the construction of a new reservoir in Kennington Lane, for the purpose of receiving the water as it flows from the Thames through the large iron tunnel above described. From this reservoir the water percolates through a filtering bank, composed of layers of coarse and fine gravel and sand, prior to its entering into another reservoir, where it also remains for some time previous to its passing to the well of the engine. Its purification thus becomes more effectual, so as to render it transparent before it is conveyed to the cisterns of the houses. One of the reservoirs being constructed several feet higher than the others, it is adapted for keeping the principal mains full of water during the nights, so as to furnish an ample supply whenever fires may occur. The various reservoirs altogether contain about 6,000,000 imperial gallons of water, and the efforts of this company to improve the condition of the water before it is allowed to flow to their tenants, indicate an earnest desire that they should receive it in such a pure state, as to be fit for beverage, or any other purpose.

The site of the South London Water Works being lower than a considerable part of the district which they supply, it requires the use of the steam-engine to effect it; but as it has both a lifting and a forcing pump, its power can be employed either to impel the water along the mains, or to fill the reservoirs. The highest point of their service is about seventy feet, which can be readily accomplished to a certain extent from the works; but the houses in that part of Bermondsey, where their principal main is laid down, cannot be supplied without the aid of the steam-engine. Its great mechanical power is required to overcome the resistance, which friction and

the action of the air oppose to the natural flow of the water along the pipes, even when the reservoirs are quite full, and have also an altitude apparently adequate to convey water three feet above the level of the ground. Indeed, in all cases where the pipes have only a very slight inclination for conveying water to a great distance, friction greatly retards the current, as well as diminishes the quantity, that those of certain diameters are estimated to convey under other circumstances; such, for instance, as the pressure of a lofty column of water, or considerable mechanical force. This is, therefore, a point which generally requires particular attention in the construction of water-works.

The supply of this company extends to more than 10,000 houses in a populous district; and their Act authorizes them to convey water to the inhabitants of various parishes, and parts of parishes, in Lambeth, Newington, Bermondsey, Rotherhithe, Deptford, Camberwell, and Clapham. Apparently extensive, however, as may be this authority, till recently they were restrained from laying down pipes, or supplying water, to the inhabitants of any house within certain prescribed limits of this large district, under a penalty of 10*l.* for every house, or building supplied; and this restriction precluded them from carrying their operations within a mile and a half of the Lambeth Works, although another clause of the Act allowed the latter to lay down pipes within 200 yards of the reservoirs belonging to the former, which was actually done. Thus restraints were imposed upon one concern, and a privilege conferred upon another, not in strict accordance with the primary objects of legislation, which ought rather to aim at promoting the benefit and security of the community. But in this case, the necessities, conveniences, and comforts of a

large population, in the southern division of the metropolis, were evidently considered of less consequence, than the exclusive pecuniary advantage of a comparatively small number of persons. The restriction alluded to has, however, been removed by an Act of the present session of Parliament (1834), so that the company will be at full liberty to compete with the other two establishments in Southwark and its environs, so as probably to render their concern more prosperous than it has heretofore been. For having increased the power of promoting their own welfare by more extensively serving the public, it may be presumed that commensurate efforts will be made for the purpose; and the competition, if prudently conducted, may be reciprocally beneficial to themselves and the inhabitants of the district. By clauses introduced into the new Act of this company, as well as that of the Lambeth Company, both are enjoined to supply *filtered water*, thus ensuring its purity. In conclusion, it may also be stated, that schemes have been proposed for supplying the south side of the metropolis from the River Wandle, by the erection of new works, but hitherto they have not been realized; and if they ever should be so, a doubt may be reasonably entertained, if better water could be supplied to the inhabitants, than that which they have at the present time, or will eventually have, when the existing establishments shall have completed all their intended improvements, for its collection, filtration, and distribution.

CHAPTER VIII.

Liverpool and Harrington Works. Abundance of Water: peculiar Method of procuring it. Steam Engines. Reservoirs. Mode of supplying the Town and Docks. Extent of Mains. Bootle Works: Source of their Supply of Water. Reservoir, &c. Project for Water Works at Manchester, under the Direction of Mr. Rennie. Stone Pipes: their failure. Change of Plan: Property transferred to a new Company. Improvements. Great Reservoir at Gorton. Mains. Fountains. Quantity of Water supplied, &c. Edinburgh: Project in 1810, for improving the defective supply of Water. Act of Parliament to realize the Plan. Crawley Springs: their great Altitude. Reservoirs. Extent and Inclination of Mains. Mode of supplying the City: its peculiar natural advantages for the purpose. Glasgow Works. Mr. James Watt's Flexible Main across the Clyde. Establishment at Dalmarnock. Reservoirs, &c. Cranston Hill Company: failure of their first attempts. Reservoirs. Filters: their Construction. Messrs. Brown and Co.'s Filter. Washing Establishment. Greenock; its Localities; mode of collecting and supplying it with Water. Reservoirs: Plan of Filtering, &c.

Having given an account of the extensive and effective means by which water is abundantly supplied to London and its suburbs, we shall endeavour to detail the different plans adopted for supplying several of the largest cities and towns in other parts of Great Britain. The distribution of water to the opulent commercial town of Liverpool, is effected by two large establishments, denominated *The Liverpool and Harrington Works*, and *The Liverpool Bootle Water Works' Company*. The arrangements and operations of both are considerable; but the mode of procuring the water supplied is rather peculiar,

and therefore a minute description of each source will not be uninteresting.

The Liverpool and Harrington Company supply water collected from springs in the bosom of the earth, by means of several very extensive tunnels, formed in a natural rock of red sand-stone, and having through their whole length a gentle descent towards large wells, from which the water is pumped by steam-engines. That the company may be enabled to convey it to every part of the town, they have erected, five different works adapted to supply the various districts; and the respective situations of these are—Soho Street, Bevington Bush, Berry Street, Coperas Hill, and Harrington Park; the latter being a part of the town which, by an Act of Parliament, the company have the exclusive privilege of supplying.

Though the quantity of water, obtained from the tunnel first constructed for the Harrington district, was considerable, yet experience proved it to be insufficient for its purpose, and therefore it was afterwards formed lower in the earth, in order to augment its productive power. As this is the most important of all the aqueducts belonging to the company, an account of it will convey an intelligible notion of the peculiar method employed. The tunnel is placed about 150 feet below the level of the ground, on which the buildings of the establishment are erected; and it consists of one principal trench, nearly 250 feet long, with five or six others much less in length, but the whole have similar dimensions, with an inclination occasioning their respective streams to unite, and be confluent to the place where the water is finally received. The magnitude of these different tunnels is very considerable. In general they have a height of twenty feet by a breadth of twelve; but when that for supplying

the Harrington district was placed lower, its perpendicular dimension was increased to about twenty-eight feet. The principal aqueduct, being constructed in the middle of the others, is not only more extensive, but lies lower in the earth, so that the water produced by the whole series of tunnels, flows together into the wells connected with the steam-engines, which are employed to elevate it to the various reservoirs for distribution.

At each of the several stations, the company have one or more steam-engines; but these greatly vary in their capacity, some of them having thirty, others twenty-four, and even only six horses' power. The whole of the engines are, however, of the high pressure kind, and usually work at about seventy-five pounds on the square inch. Indeed, the situations of many of the houses supplied, as well as the magnitude, arrangement, and extent of the mains employed to conduct the water to the several districts, necessarily require great impelling force.

To convey the water from the reservoirs, the company employ three principal mains, consisting of iron pipes, having the respective diameters of ten, nine, and eight inches; and also extending altogether to the length of more than 20,000 yards. From these large conduits proceed pipes of six, four, and three inches in diameter, the whole of which form an addition to the length of the others of about 90,000 yards. At each end of the streets there are plugs for the purpose of affording a supply in cases of fires; and it is customary to open these plugs every day to cleanse the pipes, before the water is conveyed to the houses.

Notwithstanding the very large demand for the constant and regular population of Liverpool, as well as the numerous vessels that frequent its port, the supply of water is abundant for all purposes. Moreover, its distri-

bution is so effective and complete, that whatever may be the elevation of the houses in the town, it can be conveyed into every apartment. Hence, in addition to the other domestic conveniences, many of the wealthy residents, are enabled to have either cold or warm baths in different parts of their houses.

This company supply the docks and the harbour, and have two reservoirs adapted for that particular service,—one being situate in Prussia Street, the other in Newhall Street. Both reservoirs have been formed with thick cast-iron plates, and the dimensions of the largest consist of a length of sixty feet, by a breadth of fifteen, with a depth of ten. The other has a length of thirty-three feet, by a width of seventeen, and a depth of seven. The level of water which both contain, is generally about fourteen feet above that of high water in the docks, and several persons are employed to attend to this particular service. The water is distributed by means of leather pipes, with brass boxes fixed at one end, and having also a screw adapted to a corresponding brass screw, formed at the top of the apertures of upright iron pipes, that are connected with the mains. A great number of these upright pipes are fixed along the docks and round the buildings, so that a plentiful supply is readily and quickly afforded for all purposes, and on any emergency. The quantity supplied is very large, and its average weekly amount has been estimated at about 4,000,000 of imperial gallons.

The operations of the Liverpool Bootle Works, probably equal those of the other company, and a similarity pervades their mode of supplying the town, as well as in the arrangement of their mains, with other provisions for the purpose, but the means of procuring the water is altogether different. They obtain their supply near to

the sea shore, from a number of springs which rise in a place resembling a bay in its form; and the exuberance continually produced by them, suggested the idea of rendering them useful for the service of Liverpool, many years before any water-works were constructed to realize the plan. Frequently as this productive source had been noticed, the first attempt to convert it to an advantageous use was in the year 1801, when a massive dam being formed across the lower part of the great cavity in which the water ascends so abundantly, the space was transformed into a capacious reservoir. In furtherance of the object contemplated of conveying the water to Liverpool, in 1802, Mr. Samuel Clegg,* the engineer, was employed to erect a steam-engine with two horses' power, having a pump ten inches in diameter, and a stroke of eighteen inches. The engine forced the water to the top of a tower fifty feet high, this building being sectionally divided, so that the water ascended on one side and descended on the other,† resembling in its operation that of syphon with the curved part uppermost; hence, the elevation of the water, by this contrivance, occasioned it to flow along tunnels to the reservoirs, constructed for supplying the inhabitants, and different commercial establishments of Liverpool. The small steam-engine continued in use for several years, but its power eventually proved very inadequate to its original object; and afterwards the means were greatly augmented by the erection of two other engines, one of thirty, and

* The ingenious inventor of the *Gas Meter*, *Hydraulic Main*, and various other useful machinery employed in the operations of gas establishments. *History of Gas Lighting*, p. 71, &c.

† Buildings similar to this, called *Souterazi*, are employed for conveying water to Constantinople.

another of thirty-six horses' power. This large addition of mechanical assistance required a proportional augmentation of the size of the conduits, and consequently mains of suitable dimensions were laid down; but, notwithstanding the considerable increase in the draught from source, the supply has constantly continued plentiful.

Manchester having a great population, with extensive bleaching, dyeing, and other establishments, which severally require a large quantity of clear soft water, its supply became an object of considerable importance, apparently presenting a fair opportunity for profitable speculation. Such a favourable concurrence of circumstances, prompted some enterprizing individuals to engage in the formation of a company with the view of supplying the place; but the early efforts to realize the scheme did not evince much knowledge, or skill, in processes of this description. Unfortunately for their interests, they commenced operations by adopting the defective and inefficient means formerly pursued in London, and employed wooden pipes for the distribution of the water; and afterwards that plan was changed for another equally incompetent for their purposes, unfavourable to their success, and likewise a source of great dissatisfaction to the public.

The proprietors of a stone quarry, having undertaken to make pipes of that material for the purpose of conveying water, with a view of promoting the sale of their productions, represented the qualities of the stone as being of a very superior kind. On the suggestion of Mr. Rennie, the engineer, the company therefore substituted them for the wooden pipes, which had been previously laid down; events, however, proved this measure to be both injudicious and unfortunate, for it actually proved fatal to the prosperity of the company. Whatever

knowledge or skill Mr. Rennie might possess on other subjects, circumstances afterwards rendered it evident, that his opinion of the strength and efficacy of stone pipes, was founded upon assumptions rather than facts and experiments, which alone ought to have guided his decision in such an important and expensive undertaking.

In the first instance, the supply of water was obtained from the River Medlock, at the distance of about a mile and a half from the town ; and, to secure a large head of it at that place, a dam was formed across the bed of the river. This contrivance occasioned the current to flow into reservoirs, excavated for the purpose, and whence a covered tunnel, formed in the rock, conducted it to the well of a steam-engine, with sixty horses' power, which pumped it into a reservoir on an elevated site contiguous to the engine-house.

The high reservoir occupies a space of about five acres. Its banks are very carefully constructed with earth, having a slope of twice the dimensions of their perpendicular height, and likewise covered with stones. The level of the water contained in it is usually about eight feet higher than its source at the River Medlock; and from this elevated reservoir the stone pipes were first filled with water. Though the use of them had been so strenuously recommended, their total inefficiency for the intended purpose was soon demonstrated; and, notwithstanding the precautions employed in laying them in the ground, they proved utterly incompetent to sustain the pressure applied to them. Some were entirely broken to pieces, and from others the water rapidly escaped, either through the pores or the joinings, so as to produce the serious inconvenience of almost deluging the town. The temporary annoyance to the inhabitants was very great; but the consequences of the failure of the pipes

were actually ruinous to the company, from their original cost, and the expense of laying them down having been so large, as completely to exhaust all their pecuniary means. Hence, the shares in the concern eventually became so depreciated, as to occasion the works to be transferred, in 1817, to another company of proprietors, who obtained a new Act of Parliament, incorporating them with the designation of *The Manchester Water Works' Company*.

When all their arrangements were completed, and the new company had obtained possession of the establishment, they immediately proceeded to substitute iron pipes for those of stone, at the same time judiciously availing themselves of all the improvements which had been introduced, both in the form and the mode of laying them down. Afterwards, for the period of nearly four years, efforts were made to derive water from another source instead of Medlock; and, for effecting this purpose, the company purchased sixty acres of land at Gorton, situate between four and five miles from Manchester. This new acquisition was formed into a vast reservoir; and that it might effectually answer the end for which it was constructed, its elevation was greater than the other by nearly thirty feet. This magnificent reservoir being so capacious, in order permanently to supply it, methods were adopted for collecting water from all the surrounding sources wherever it could be obtained. It became likewise necessary to construct various other important works, for different purposes, and particularly to obviate any inconvenience resulting to the occupiers of the lower grounds by intercepting streams, or any other means of irrigation subsisting previous to the construction of the reservoir.

Having thus secured the sources for obtaining an

ample supply of water, the mode of efficiently conveying it to the inhabitants, so abundantly as to satisfy their utmost demands, was equally essential. For this purpose the general arrangement of the pipes consisted of one principal main, commencing with a diameter of twenty inches, and gradually diminishing to ten; and from this other pipes, of different dimensions, branch off at the corner of every street.

There are likewise some other circumstances connected with the operations of this establishment, which may deserve attention. As the water flows from such an elevated spot, in its course it alternately ascends and descends, to arrive at its destination; hence, in some cases, the services are attended with difficulty, but this is rather diminished, by increasing the number of valves in the same range of pipes. These valves being numerous, occasion the employment of several men to open and shut them at proper times; besides, this service requires both skill and attention on their parts, to prevent complaints respecting either interruptions, or any deficiency in the supply. The houses in all the principal streets and places of the town, have either cisterns or butts to receive the water, which flows into them from the mains at regular stated times; but in the suburbs a different mode is adopted, for the inhabitants procure it by turning a cock at small fountains, whenever necessity or convenience may require a supply. As these contrivances are very simple in their construction, they easily open and shut, by means of a small key, one of which is delivered to each tenant. The number of houses supplied being from 15,000 to 20,000; the whole quantity of water averages daily about 1,500,000 gallons. The advantage of these water-works, to this great manufacturing town, will therefore be obvious.

Generally, as was formerly the practice, to obtain water for domestic and other uses from wells, by means of a windlass and bucket, or the aid of pumps, it has long been gradually declining in the great towns and cities of this country. By the establishment of water-works, in such as are most populous, the method of supplying it for domestic purposes, has been simplified and facilitated. Norwich, Bath, Birmingham, Sheffield, and many other places, possess these contrivances to benefit their inhabitants; but as they resemble several of those already described, both in principle and operation, any particular detail of each will be unnecessary. The defective supply of water to Exeter had long been a subject of complaint; however, a project has recently been executed, for abundantly conveying water to its residents from the river Ex, so as to obviate the serious inconvenience heretofore experienced. Indeed, it is far from being improbable, that, ultimately, works of a similar nature will be quite as common as those for the supply of gas.

The City of Edinburgh being chiefly erected on eminences, many of its inhabitants formerly experienced great difficulties in obtaining plenty of good soft water for common domestic use, and hence originated an attempt, in 1681, to procure a supply that should be adequate to their wants. The method adopted for the purpose consisted of a train of leaden pipes, three inches in diameter, and 13,520 feet in length, to convey it from the village of Comiston, to a reservoir constructed on Heriot's Ridge. As these pipes eventually proved too small for their object, the defect occasioned the laying down of another train, in 1722, having a diameter of four inches; but during the subsequent fifty years, the population progressively increased, and consequently required a pro-

portionate addition to the supply, which induced the magistrates in 1787, to adopt a main of iron pipes, five inches in diameter. Though this measure had the effects of augmenting the quantity of water; nevertheless, the introduction of various improvements, and the erection of buildings, &c., rendered it necessary to have recourse to some other springs, at a greater distance from the city. In 1790, an additional main of iron pipes, seven inches in diameter, was therefore laid down, to convey water from Green Craig to the Castle Hill, at an expense of 20,000*l.*; and this source furnished about 80,640 cubic feet in the course of every twenty-four hours.

Notwithstanding the successive efforts to augment the supply of water, so as to render it fully commensurate to the various wants and uses of the residents of Edinburgh, and the improved state of the city, still its deficiency gave rise to numerous complaints. The establishments for effecting this important object, being the property of the corporation, the dictates of duty, as well as motives of interest, concurred to urge the adoption of means for obviating the alleged inconveniences. Hence, in 1810, the subject engaged their particular attention; and, in the first instance, the devising of an effective remedy was confided to a committee, composed of the most opulent, enlightened, and influential inhabitants. Afterwards, another committee was formed to afford their assistance, and the persons selected on this occasion, were either Professors in the University of Edinburgh, or engineers, among whom may be enumerated Dr. Hope, Professor Playfair, Messrs. Telford, Rennie, and Jardine;—the researches of the latter being chiefly directed to discover sources from which it would be practicable to obtain an abundant supply of good water. As the latter was a paramount consideration, Dr. Hope analyzed the different waters

which Mr. Jardine pointed out in the environs of Edinburgh; and the results of his scientific examinations were detailed in a report to the committee, who likewise, in 1813, received another report from Mr. Telford, containing a plan and description of the different works that would be necessary for the most ample supply to the metropolis of Scotland.

The mass of useful and satisfactory information afforded by the different documents, occasioned their publication, which excited a high degree of interest. A number of persons soon united to accomplish an object so important; and the principal promoters of the plan consisted of the magistrates, as well as many of the most wealthy and intellectual inhabitants of Edinburgh. In 1819, the subscribers, who had associated for carrying the scheme into effect, were incorporated by an Act of Parliament, authorizing them to raise a capital of 135,000*l.* in shares of 25*l.* each; and also to assign 1200 of them to the corporation, as a compensation for their interest in the then existing establishments, for supplying water to the habitations in the city and its suburbs.

The source, whence it was determined to procure the water, had its rise on the south side of the Pentland Hills, at the distance of about seven miles from Edinburgh, and denominated Crawley springs; but though these produced great abundance, the quantity was considerably augmented, by collecting it from some others on the north side of the Pentlands, by means of lateral conduits, which extend for about half a mile higher in the valley than the site of the former. As the ground of the valley consisted of a bed of gravel, forty feet deep, it proved peculiarly advantageous, by forming a natural filter for the water, which percolated through the mass before it arrived at the spring-head, which is about 560

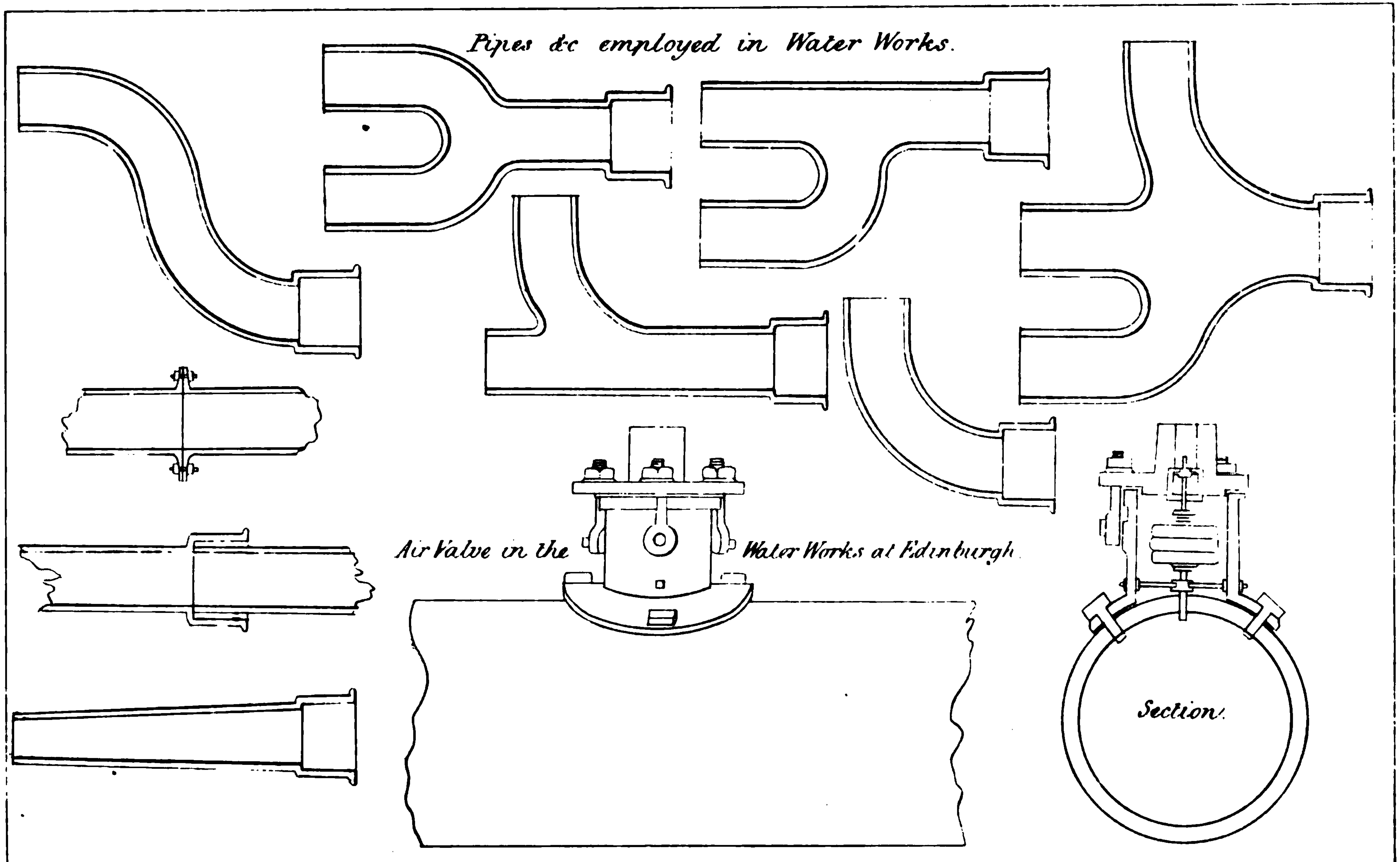
feet above the level of the sea, and 360 feet higher than the highest street in Edinburgh.

At Crawley springs is the Fountain-Head House, which has a length of sixty feet, by a breadth of thirty, being covered with an arched roof, and surrounded by a wall. This building contains a cistern forty-five feet long, fifteen wide, and six deep, the whole constructed with free stone. The different reservoirs for supplying Edinburgh, are not only capacious, but very conveniently situate for effecting their objects. One of them is on Heriot's Green, having a circular form, and containing a basin thirty feet diameter, with a depth of ten feet. It is about 270 feet below the Fountain Head;—its purpose being the supply of the southern part of the city. Another reservoir, constructed on the Castle Hill, has a length of forty-three feet, by a width of twenty-eight feet, with a depth of seven feet six inches: the site of this is about 230 feet below the Fountain Head, consequently its altitude is forty feet above the other, and it supplies the northern district of Edinburgh. The average elevation of the streets supplied from the reservoir at Heriot's Green, is about 237 feet above the level of the sea; and the distance of the reservoirs from the Fountain Head is about nine miles; but the supply of Leith, from the same source, being contemplated, pipes have been laid down for carrying it into effect.

With a view to obviate any inconvenience that might result from the flood waters to the mills on the river Esk, a very capacious reservoir has been constructed in the valley of Glencorn. The height of its embankment is about twenty-four yards, and the breadth at the base above 150, its distance from the springs being about one mile. As the expense of constructing this and all the other works far exceeded the sum authorized to be

raised by the Act obtained in 1819, the Company procured another Act in 1826, to empower them to augment their capital to 253,000*l*.

The water is conveyed from its source by a train of strong iron pipes, which vary in their capacity, diminishing as they approach Edinburgh, from twenty to fifteen inches diameter. At the Fountain Head, those of twenty inches commence the series, and continue for a considerable space, when pipes of eighteen inches diameter are introduced to the end of the first 18,300 feet; of which the descent is about sixty-five feet. For the remaining part of the main, pipes of fifteen inches are employed, and the fall of this space is 286 feet, in the length of 27,900 feet. In some parts they have an undulating course, and ascend and descend twenty or thirty feet. The main passes through two tunnels,—one of them excavated in the solid rock of the Castle Hill, for a length of 1740 feet, and 120 feet below the reservoir;—the other being conducted under Heriot's Green, seventy or eighty feet below its surface, and having a length of 2160 feet. The reservoir on the Castle Hill communicates with that on Heriot's Green, and large pipes branch off from both, for the plentiful supply of the city, in every direction. The altitude of the source being about 360 feet above the level of Edinburgh, in order to prevent any interruption from occurring in the flow of the water, by the air collecting in the pipes through so great a length, a number of cylindrical vessels, four feet high and eighteen inches wide, have been placed above the pipes, at convenient distances, where, by means of a cock or valve, the air can be discharged without any escape of the water. The strength of the pipes is adapted to sustain a pressure equal to a column of water 800 feet high.



G. F. Madeley lith. 3 Wellington St Strand

At Edinburgh the mains are constantly kept full of water, and as every house may have small service pipes from them, by the payment of a regular annual sum, the unrestrained use of the water is allowed. From its abundance, and the great height of the reservoirs, the pressure is such as enables every house to obtain whatever water may be requisite for its purposes; but, notwithstanding the facility thus afforded for procuring it, in some parts of the Old Town, people still obtain their supply by the means formerly in use, and purchase it in small quantities from men and women, who earn their subsistence by carrying it in vessels on their backs to the high houses.

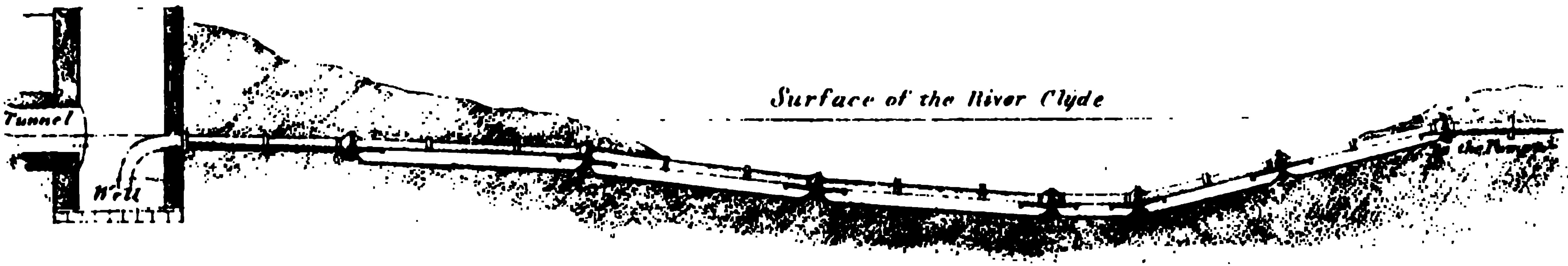
The stupendous undertaking for supplying Edinburgh with water has certainly been aided by peculiar local advantages, which are combined with some ingenious contrivances of art, so as admirably to effect their purpose. From the lowest reservoir having an altitude of about fifty feet above the average level of the houses, the water naturally flows into the highest stories without the use of any extraneous mechanical force. The inhabitants have likewise the liberty to take the water at all times, without restriction as to quantity; and the supply is so regular and plentiful, as to obviate any reason for complaints. Hence, the establishment may perhaps be deemed as complete and effective as any of its kind, in this or any other country. Mr. Jardine, the engineer employed in the first instance to discover proper sources of water, superintended the execution of the works.

The City of Glasgow being much larger and more populous than Edinburgh, has consequently given rise to varied and extensive attempts to supply the inhabitants with water for domestic use. Two establishments engaged in effecting this object; one of them designated the

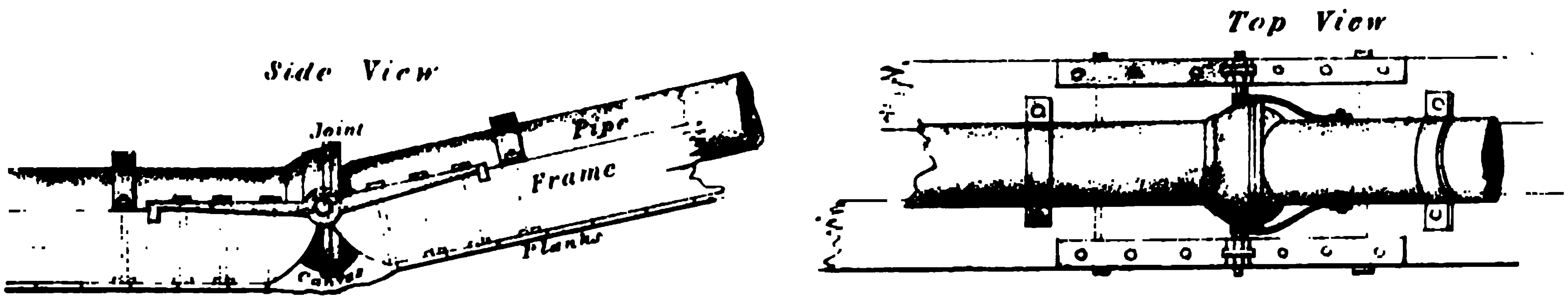
Glasgow Water Works, and the other the Cramston Hill Water Works. To construct the former an Act of Parliament was obtained for incorporating a company, in 1806; and another Act, in 1809, authorized them to augment the pecuniary means for accomplishing their purposes. The latter became a corporation by an Act passed in 1808; and in the following year, another Act increased their powers to modify and extend their undertaking.

The Clyde furnishes the water supplied by the Glasgow Water Works, and it is obtained by means of a tunnel constructed on the left, or south side of the river. This tunnel, being elliptical in its shape, has a perpendicular height of about seven feet, with a transverse of about four feet six inches; and it also forms a curve parallel with the bend of the river, at about fifty feet from its margin. It is placed about ten feet lower than the level of low water in the Clyde, and is estimated to yield a supply of 250,000 gallons per hour. Its situation is at a place called Dalmarnock, where the bank of the river consists of a stratum of sand, forming a kind of natural filter for the water.

Considerable as was the quantity of water thus obtained, circumstances required it to be greatly increased, and, therefore, three large channels were afterwards excavated on the bank of the river, in the space of ground which contained the other aqueduct. The additional channels were formed at about six feet above the latter, so that the water passed into them from the river, through pipes placed at each of their extremities. Besides, the pipes not only extended into the bed of the river, but each had a cock, or valve, so affixed to it, that its orifice might be opened or closed, to regulate the flow of water, according to circumstances. Some smaller aqueducts were also



Flexible Main across the bed of the River Clyde, contrived by James Watt Esq.[r]



Portions of the Flexible Main.

J. B. Madeley lith. 3 Wellington St. Strand.

constructed between the different channels, and both the form and materials of these tunnels were similar to the principal one with which they communicated. The quantity thus obtained essentially contributed to augment the supply; for the tunnels being situate in the sandy soil, forming the bank of the Clyde, the water readily percolated from their channels, to flow into the principal aqueduct, so as to furnish such an abundance, as would be quite adequate to the whole consumption of the City of Glasgow.

It is remarkable, that although the Glasgow Water Works' Company procure their water by aqueducts constructed on the left side of the Clyde, nevertheless, the principal works for supplying the inhabitants, as well as the city itself, have their sites on the right side of the river, consequently, the water from the reservoirs on its banks is conveyed across the stream. The mode of effecting this, at first, presented a difficulty; but it was surmounted by the genius and skill of the celebrated Mr. James Watt, who devised a flexible main, constructed with iron pipes, and so connected as to adapt its form to the bed of the river. That part of it which was laid across the bed of the river, consisted of pipes nine feet in length, exclusive of the joints, and having a diameter of fifteen inches. Some of the joints were formed in the usual manner; but others were made similar to those commonly called ball and socket, or universal joints. By means of these, the whole train of pipes being properly and firmly connected, the main was laid upon massive wooden frames, consisting of logs placed parallel, and joined together by very strong iron hinges. The pipes and frames were put together on the south side of the river, and the end of the pipe intended for the north side

was stopped with a plug; when a trench having been previously prepared to receive them, by the assistance of machinery, the flexible conduit, with its bed of wood, were hauled across the stream—the moveable joints of the pipes, and the hinges of the frames, allowing the whole range to assume the form required by the bottom of the Clyde. The operation was aided by pontoons, and the machinery employed to haul it into its place, was, of course, fixed on the north side of the river. When the plugged end of the main emerged from the current, it was immediately opened, and connected with the pipe leading to the reservoir, where the pumps were situate. For the purpose of protecting the main from sustaining any injury by vessels passing along the Clyde, the whole of that part, which lies under water, is covered with gravel and stones. This ingenious and useful contrivance was executed in 1810; but the increasing demand for water occasioned the adoption of another of the same kind, twenty-eight inches in diameter, in 1818; and, subsequently, a similar one, thirty-six inches diameter: the two largest are employed to convey filtered water only.

The number of steam-engines at Dalmarnock are six; four of sixty horses' power, and two of thirty. The company have two intermediate stations in the City of Glasgow; one of which is situated in Rotten Row, and consists of a covered reservoir, about fifty feet long, thirty wide, and fourteen deep. It is constructed with bricks that are covered with Roman cement, and it contains a stand pipe to regulate the pressure: the level of the water in it is about 157 feet higher than the average level of high water in the river Clyde, and therefore corresponds with one of the most elevated parts of the

city; but the summit of the stand pipe has an altitude of twenty-six feet above the level of the water in the reservoirs.

The other establishment has its site in Duke Street, and it is not only much lower, but more extensive, than that in Rotten Row. It comprises two large open reservoirs, with a building that contains a small reservoir, having for its sole object to regulate the pressure, whence it is denominated the *Forcing Tower*. At this place two steam-engines are erected; one of twenty-six, and the other of twelve horses' power. It has also a complete workshop, adapted for the different operations connected with the proper maintenance of the establishment. A space of about eighteen feet separates the two large reservoirs, both of which are lined with bricks; and their respective dimensions consist of a length of 186 feet by a breadth of ninety-two feet: the level of the water in each is seventy-six feet above the point whence it commences flowing into the mains. The small reservoir, or Forcing Tower, for regulating the pressure, is about eleven feet square; its bottom being formed with cast iron plates, and having in its centre a pipe, which shows the limit of pressure, when the water is forced to issue from its uppermost orifice. In the same building, which is about fifty feet high, there are also some hydraulic contrivances for readily managing the current of water, as it may be impelled by the steam-engines from Dalmarnock. This machinery is both ingenious and simple, affording the means of varying and adjusting the pressure and direction of the water, so that it may flow into the several mains, though different both in their dimensions and heights.

In general the houses of the City of Glasgow are very lofty, and consist of several stories, each being usually occupied by a different family; nevertheless, the altitude

of the reservoirs facilitates the abundant supply of all the residents, whatever may be the height of their dwelling-places. Hence, the pipes for conveying the water, are so adapted to the interior of the houses, that the occupants, even of the highest stories, receive an abundance. A considerable quantity is distributed by means of fountains, which are placed by the side of the foot-paths, or in the alleys, called closes; thus accommodating every class and situation within the city and its precincts. Such are the important operations of one company, to afford water to a very large population; but the exertions of the other establishment, to effect the same purpose, are entitled to attention, both as regards their peculiarity and magnitude.

Unsuccessful attempts to attain an important object, have frequently been productive of much useful information, inasmuch as they have occasionally led to improvements, which ultimately proved beneficial to the public, though, in many cases, the causes of considerable pecuniary loss to individuals. The early efforts at Glasgow to effect the filtering of the water before it was supplied to the inhabitants, afford an apposite illustration of this remark; for all the first experiments failed to realize the intended purpose, though made at the expense of about 30,000*l*. Various instances, of a similar unfortunate kind, might be adduced, displaying the bold and meritorious struggles of patient industry and resolute perseverance to overcome great difficulties, unappalled by more than ordinary discouragements. This was conspicuously the case of the company who established the Water Works at Cramston Hill—their operations, during several successive years, having proved signally disadvantageous, from causes which have generally produced similar effects.

The Glasgow Water Works' Company having involved themselves in considerable pecuniary trouble, by great and useless expenditure in the construction of their first filters, besides other attempts of which the results had been unsuccessful, the Cramston Hill Company considered the circumstance as offering a favourable occasion for elevating their own concern. Hence, with the view of accomplishing their purpose, some land was purchased upon the bank of the river Clyde, contiguous to the most populous part of the City of Glasgow, where buildings, steam-engines, and other works were erected. But exclusive of this establishment, an extensive tract of land was obtained at Cramston Hill, on which reservoirs were constructed for collecting a large quantity of water, and afterwards one for a filter, with another to receive the filtered water; but although the filter was an improvement upon that constructed by the Glasgow Company, yet its results proved unsatisfactory.

If these attempts proved less effective than had been very confidently anticipated, the relation of a few circumstances will convey some notion of the magnitude of the exertions to attain the object. By the assistance of a steam-engine, the water of the Clyde was impelled over a hill, 100 feet higher than the usual level of the river, and likewise situate at the west of the city, where a reservoir of large dimensions received it, in order that it might remain some time, for its feculence to subside. Afterwards it was conveyed by four iron pipes into four long channels, constructed in the middle of a stupendous heap of sand, collected for the purpose. The width of these channels at their surface was about thirteen feet, and they were placed parallel to each other, at about the distance of ten feet: but in the intervening space between them, the bottom was paved, for three or four feet, so as to

form ditches, and furrows, with upright sides. Over the latter small arches were constructed with stones, laid together without any cement, and also placed irregularly for the purpose of leaving numerous interstices. To render the plan more complete, the arches were finally covered with small flint stones, on which was placed a layer of fine sand. When the large channels were filled with water, it percolated through the heap of sand, flints, and stones, so as to descend into the ditches and furrows, which had a slight declivity towards the reservoir, whence it flowed to the upper stories of the houses in the city, by means of syphon pipes, adapted for that purpose.

Several other operations, in addition to those already related, likewise affected the prosperity of this establishment. As the works to procure water had been erected below the city, exclusive of the water supplied not being sufficiently clear, the public had some other objections to using it, though offered at the lowest possible price. Necessity, therefore, imperiously constrained the Cramston Hill Company to seek for another situation, affording the means of obtaining water from such an eligible source as would enable them to satisfy the public, and continue the competition with their powerful and more successful predecessor. This consequently occasioned the construction of some new works at Dalmarnock.

Unfortunately, however, for the interests of the company, the site selected for their object was one where nature had interposed an insurmountable obstacle to success. It was situate on the north side of the river Clyde, and in order to obtain clear water, steam-engines were erected, and aqueducts with other works constructed, similar to those of the rival company. But here the soil, being intermixed with mineral substances, so affected the

water so as to render it unfit for drinking, or its usual purposes. Hence, different experiments followed each other during several successive years; and while these trials were making, the company lost the greater portion of their customers. One of the schemes adopted for obviating the inconvenience, was the formation of an aqueduct, by which it was conceived that the mineral water would be repelled, by the greater pressure of that of the river. The experiment was made, and proved successful; but some members of the managing committee proposed another process that was finally adopted and executed, though it ultimately failed.

The latter plan required, for effecting its object, the construction of a large reservoir on the bank of the Clyde, with such a depth that its bottom should be lower than the lowest level of the water in the river, and also formed in such a manner that the water should descend into it by its own gravity. At the bottom of the reservoir, small cylindrical tunnels, in parallel lines, were constructed with bricks, made in the form of wedges, and laid together without mortar. The diameter of the tunnels was about two feet, the distance from each other about twenty-three feet, and the whole number about thirty. Layers of gravel and coarse sand were laid over each, so that their external appearance resembled that of so many ridges and valleys. When the reservoir was filled, the water passed through the sand, gravel, and interstices of the bricks, and flowed along the tunnels into a reservoir, from which an aqueduct, of four feet diameter, conveyed it to the well of the steam-engine for distribution.

For occasionally cleansing the filters, a very singular method was adopted. All the small tunnels terminated in one that had a longitudinal direction; but above the latter was fixed a large cast iron pipe, which had a com-

munication with a pump, situate in the building containing the steam-engine. From this pipe proceeded various bent branches descending to the lower part of the valleys, which were paved, and on the same level with the tunnels. The end of each branch pipe had a very simple wooden stopper, so adapted as to open or close, by means of a line and screw: hence, whenever it was necessary to clean the filter, by opening the ends of the pipes, one of which was appropriated to every valley—the water flowed into each separately: afterwards, by working the pump, the water was put in motion so as to pass across the sands in a direction contrary to that which it previously had, and by mixing with the sediment, carried it away. Though at first this process was admired, the muddy water sometimes had the effect of putting the pump out of order; besides the time it required, with the cost of repairs, proved to be more than a counterbalance to the utility of the plan, and therefore the practice was eventually abandoned.

The failure of this attempt had not merely the effect of occasioning a farther diminution of their customers, but the great expense incurred by it, as well as the removal of their steam-engine and other apparatus, involved the company in serious difficulties. Accumulated misfortunes and disappointments did not, however, discourage them from making farther strenuous efforts, to accomplish the original purpose of their enterprize. Indeed their conduct affords an useful lesson to men who may engage in the pursuit of a great object, by showing that difficulties ought rather to stimulate, than relax their exertions to realize the purpose in view.

Expensive and disastrous as their experiments had hitherto proved, another of considerable magnitude was consequently determined upon; and therefore near to the

large reservoir, which had disappointed the expectations formed of its efficacy, one was constructed of similar dimensions, but about fifteen feet deeper, as well as sufficiently capacious to contain from 50,000 to 60,000 cubic feet of water. But on this occasion, with the view of ensuring a successful result, the company employed Mr. M'Kain, an engineer, to make researches concerning the best modes of filtration, so that they might be substituted for those which had previously been adopted. Having zealously fulfilled his commission in making the necessary inquiries, the result was his proposing a scheme; though prior to its execution, he prudently tried his intended process, on a part of the ground adjoining that which was occupied by the inefficient filter. In this experiment, the water of the Clyde was conveyed by a pipe communicating with its bottom, into a kind of basin formed with planks, and resting upon another structure, that had formerly been erected on the bank of the river, to supply the first filter; but the subsequent description of the larger plan, will convey an intelligible notion of the whole contrivance.

Mr. M'Kain's project for filtering consisted in the formation of a certain number of wells, about ten feet in diameter and six feet deep, arranged in such a manner as to resemble the divisions of a chess board. The whole had a communication with each other by means of pipes, having in the middle of them a cock or valve to regulate the flow of water, so that it might pass slowly to the filtering apparatus for its depuration. The several wells were carefully constructed with bricks placed together without mortar, but covered with planks, and forming a level surface with a thick stratum of sand, through which the water ascended to flow into a reservoir. It was calculated

that with a head pressure of from two to four feet of water, ten superficial feet of sand, filtered a gallon per minute. All the efforts of this company to ensure success, however, proved unavailing, and their losses ultimately constrained them to enter into an agreement with the other, for the disposal of their works, so as to form one concern. To ratify the agreement, an Act of Parliament was obtained during the present session (1834,) into which a clause has been introduced to regulate and limit the rate of charge for the supply. Both establishments furnish the City of Glasgow with a quantity of water, which daily amounts to 3,500,000 gallons.

Besides the filters employed at different water-works at Glasgow, another, which has been formed at the private establishment of Messrs. Brown and Company, is particularly deserving of notice. It consists of two concentric wells, one of which is formed within the other. The interior diameter of the largest measures about sixty feet, and that of the smallest sixteen feet, with a depth of about twelve feet. The space between both is filled with clay, laid slopingly to about five feet from the edge of the outer part, and to seven feet about the wall encircling the inner well. At this depth of seven feet, orifices are made of about one foot square, and filled with tiles, placed together without mortar, so as to form tunnels from one well to the other. To within about one foot of the margin of the exterior well, the space is filled with sand, and it is calculated that with this surface nearly 3000 gallons of water are filtered in an hour. The surface of this filter requires to be cleansed every three months; and the object of the inner well being the reception and transmission of the filtered water, for the latter purpose, a pipe is placed at the bottom, to convey it to a reservoir, from which a

steam-engine pumps it for the purposes of the establishment.*

At Glasgow exists an useful institution, so peculiar and convenient, as to render a description of it not an irrelevant conclusion to this detail. On the bank of the Clyde a large building has been constructed, at the expense of the city, for the sole purpose of accommodating persons who may choose to avail themselves of the advantage of conveying their linen there to wash it, and where persons take great care of it for a very small sum. The place is sufficiently capacious for 200 scourers, or washers, to work at the same time; and it is furnished with a great number of large and small tubs, as well as covered seats for sitting upon. The charges are regulated according to the time and space occupied. The price of hot and cold water for one washer, during a whole day, is about fourpence; but for half a day, threepence. The place for a large tub is charged one penny a day; but for a small tub only a halfpenny; and the price of a seat is fixed at a halfpenny. Adjoining the building is a large inclosed grass-plot, where each may lay the linen in perfect safety, under the care of a person who is employed for that purpose only; and the daily charge for his service is from threepence to fourpence, according to circumstances; but double the sum for a whole night. The convenience afforded by this establishment at Glasgow, may, perhaps, induce other large towns to erect similar places for the same purposes, inasmuch they might be conducive to convenience and economy. Besides, they would tend to obviate a domestic annoyance, which has formed the sub-

* As this filter clarifies about 3000 gallons an hour, or 70,000 in a day, does not its efficiency, as well as that at the Ducal Palace in Venice, suggest the practicability of constructing, or modifying, the reservoirs at water-works, so as to render each *a filter?*

ject of a very humorous descant by an ingenious female poet—the *troubles* and *horrors* of " *Washing Day*."*

Greenock, in Scotland, affords a remarkable instance of the advantages to be derived from the extensive and powerful resources of art, in overcoming local difficulties. During a long period, and probably from the first building of the town, its inhabitants occasionally experienced serious inconveniences, in obtaining sufficient water for their common domestic purposes. As they chiefly relied for their supply upon the rivulets which had their origin in the neighbouring eminences, the quantity was often very scanty, particularly in dry seasons, when the sources generally failed, and necessity compelled them to procure water from a distance, by the usual incommodious and expensive methods. However, in 1824, Mr. Thom, a skilful engineer, contrived a plan for regularly and plentifully supplying the place; and fortunately under the auspices of Sir M. S. Stewart, a company of proprietors was soon formed for the purpose of realizing the scheme. Besides the collecting of a large quantity of water, it also included the process of filtering it before it was conveyed to the houses; and as convenience and utility formed the principal objects in constructing the works, a concise account of them may not only be interesting, but will probably exhibit in a favourable point of view, the qualifications of the projector.

The town is situate on the south side of the mouth of the river Clyde, at the foot of a group of mountains, from which issue several streams, but these unite in a valley, where they take the name of *Shaw's-water*, and flow into the sea at Inner Keep, to the west of Greenock. Mr. Thom at first entertained the idea of interrupting the

* Mrs. Barbauld.

different streams in their course, by constructing a dam, so that their concurrent produce should be directed into a vast reservoir, sufficiently capacious for supplying at least four months consumption, during the very dry seasons. The capacity of this reservoir was estimated at 284,678,550 cubic feet; but the plan also comprised several others:—one called the *compensation* reservoir, calculated to contain 14,465,890 cubic feet; another, named *auxiliary*, adapted to receive 4,652,770; besides five smaller, which together would be capable of holding rather more than 6,000,000 cubic feet. Though these various basins afforded the means for storing 310,000,000 cubic feet of water, Mr. Thom deemed it possible to collect 600,000,000 by uniting some other streams, which he had noticed, and saw the practicability of directing their course into the same channel with the former. Indeed a careful examination of the localities of Greenock led him to the conviction, that not a doubt need be indulged with regard to obtaining such a plentiful quantity of water, as would be adequate for amply supplying the inhabitants at all times, and in every season, as well as the demands of the various other establishments of the town.

In order to render the plan as completely effective as possible, the company were desirous of having two distinct lines of supply, one for the western, another for the eastern part of the town, and each being adapted to afford to the mills on both sides at the rate of 1200 cubic feet a minute, during twelve hours for 310 days of the year. The quantity of water requisite to realize this object was estimated at 535,680,000 cubic feet. It was also intended to give to every inhabitant of Greenock two cubic feet, and as the number of population amounted to 25,000, for this purpose, 18,250,000 cubic feet only would suffice. Hence, if it were possible to procure 600,000,000 cubic

feet, the conclusion was evident, that the remaining very large quantity would be adequate to the abundant supply of all the different trading concerns, or applicable to a variety of other objects.

The above circumstances evince the attention and consideration bestowed upon the subject, previous to the plan for supplying Greenock being carried into effect; and the mode finally adopted for procuring the water was admirably adapted, as well as completely effective, for all the purposes contemplated. The mountains, at the foot of which the town is erected, being near to the sea, the abundant dews and occasional rains produce numerous small streams that issue from different points and heights. With the view of collecting the whole of the water flowing from these sources, channels have been excavated at various altitudes, to nearly the tops of the mountains, in order to intercept all the streams, and convey their produce to reservoirs, constructed for receiving and preserving the great mass of water. The fact also deserves notice, that instead of 600,000,000 cubic feet being obtained, two years' experience proved that more than 700,000,000 might be collected; consequently, as the reservoirs were capable of containing a quantity of water completely adequate to more than six months' supply, the means were afforded of making such an ample provision, as would not only be sufficient for all the demands of those dry seasons, which commonly occurred, but that a superabundant quantity might be likewise accumulated and preserved, during several rainy periods, to compensate for any deficiency arising from a succession of dry seasons.

At first the water was conveyed to the houses from the reservoirs, without being filtered; but as the whole quantity required for daily consumption amounted merely to 50,000 cubic feet, its filtration was determined upon pre-

vious to supplying it to the inhabitants: consequently, three reservoirs were constructed for the purpose, and another for receiving it, after the process of clarification. Each of the filtering reservoirs has a length of fifty feet by a breadth of twelve, with a depth of eight; and the filters are formed with fine and coarse sand to the thickness of five feet. A separate conduit, about fifteen inches square, conveys the water from the reservoirs to the filters, which are situate at about 200 feet above the town; and adjoining them is the basin that receives the water after filtration; the latter being sufficiently capacious to contain rather more than one day's supply. The reservoirs employed for the peculiar object of affording water to the inhabitants of Greenock, having such a great altitude, it constantly flows to their residences, so that they use it for all their purposes without any restraint, in the same manner as at Edinburgh and Glasgow. Besides, it may not be undeserving of particular remark, that the reservoirs regularly supply a large quantity for the operations of several mills, which is probably the only instance of the kind in this country.

CHAPTER IX.

Wells at Athens: their antiquity; manner of procuring the Water. Construction of the Wells in Thrace. Canals of Egypt, for distributing the Inundations of the Nile. Egyptian contrivances to convey Water over Mounds, &c. Old Cairo: Aqueduct and Machinery for raising Water to Reservoirs. Ponds. Deep Well at Cairo. One Fresh Water Spring in the Country. Chinese methods of taking Water from Rivers and Pools: their Chain Pump: manner of working it similar to the Tread-mill. Cochlion. Persian Wheel. Chinese Water-wheel, formed with Bamboos. Water-wheel with hollow rim, arms, and axis. Various Devices for preserving Soft Water. Cisterns at Jerusalem and Alexandria. Venice: Reservoir at the Ducal Palace: its Construction and Mode of Filtering. Proportionate Quantity of Rain Water. Vast energy of Capillary Action. Atmometer. Principle of Filtration. Lisbon Aqueduct, and plan of supplying the Inhabitants. Algiers. Malta. Superiority of the means adopted in Great Britain.

As wells and fountains were the first artificial contrivances of mankind, for procuring a supply of pure water for beverage and other domestic purposes, so the general use of the same devices, not only continues, wherever civilization has made but little progress, but even at the present time, among highly civilized nations, the rustic portion of the population obtain a great part of it, for common exigencies, by similar means. The benefits derived from them, as well as the familiarity with such useful objects may, perhaps, be the principal reason for their frequent occurrence, in the similes and metaphors, of rural bards and sages of all ages and every clime.

Apparently simple as may be these inventions of antiquity, they present some varieties and peculiarities, which render them interesting to philosophical curiosity. The wells formed during the primitive ages of Greece, had a massive marble cylinder placed at their top, and as the water ascended near to the surface, it was obtained by means of a bucket, which had a rope made of twisted herbs attached to its handles. As this was the practice at Athens, it is probable that the inhabitants were unacquainted with the method of raising it, either by a windlass, or the common lever. The mode of procuring the supply from their wells, by the use of a rope evidently continued through centuries, for among the interesting and instructive remains of that renowned people, some of the marble cylinders have actually grooves of two or three inches deep, produced solely by the friction of the ropes against their sides.

Water is stated to have been the sole beverage of the Greeks in the early periods of their history; and to this cause may, perhaps, be chiefly ascribed the high estimation they generally entertained for the wells. The inhabitants were in the practice of resorting to, and assembling together around them, not merely to procure what was necessary for their daily wants, but also for the purposes of social conversation and public festivities, of which music, dancing, and other amusements, formed a principal part. Mr. Dodwell, who travelled in Greece, relates that the circular marble top of a well at Corinth has ten figures of divinities ornamenting it, and of these he has given a representation, at the same time stating such decorations to be common to the sacred wells of the Greeks. The utility of such structures rendered them objects of peculiar regard and veneration, from conducing both to their wants and enjoyments; but, as the

population and prosperity of Athens and Corinth increased, the principal supply of water was probably derived from other more distant sources. Indeed, the vestiges of aqueducts in their vicinity, evince the correctness of this conclusion; and contrivances of the kind are evidently implied, in the following verses of Homer's description of the gardens of Alcinoüs:—

> " Two plenteous fountains the whole prospect crown'd:
> This through the gardens leads its streams around.
> Visits each plant, and waters all the ground;
> While that in pipes beneath the palace flows,
> And thence its current on the town bestows:
> To various use their various streams they bring.
> The people one, and one supplies the king."*

The construction of the wells of Thrace differed from that of Athens, and consisted of an arched excavation in the side of a rock, or other declivity, containing a spring, with a flight of covered steps and the front by an arch, to afford the means of descending to obtain the water.† Another kind of well was likewise once common in various parts of Europe, from which the water was elevated by the aid of a large lever, having the bucket at one end, with a counterpoise of stones attached to the other; and this contrivance is said still to be employed at some places in Rumelia. Besides, in Turkey, casual circumstances have suggested the plan of rendering the cavities, formed by the sides of the roads, either by nature or art,

* Odyssey, B. VII.

† A well of this kind is situate in a field at the west side of Hampstead, and at the distance of about 500 yards below the church; but there are many others of the same description in different parts of Great Britain. Such contrivances were objects of great care and attention prior to the invention and use of pumps: that at Hampstead was protected by the Act of Parliament during the reign of Henry VIII. for allowing the citizens of London to obtain water from the bottom of the heath.

subservient to the same useful purpose; for wherever springs constantly supplied them with water, they have been inclosed and converted into fountains, so as to preserve the water clean and pure, to allay the thirst, or afford the means of ablution to travellers; and structures of this kind are often to be seen far distant from any of the habitations of man.

Probably for a long time before the invention of pumps, the use of the windlass and bucket to raise water was adopted in England, from the contrivance being employed in mining operations. But whether such a supposition be correct or not, the exigencies of men in different countries, arising either from climate or other causes, have stimulated them to exercise their inventive powers in devising contrivances for ensuring a supply of water for their various wants and conveniences. As some of them display much ingenuity, a description of a few of the most remarkable will not be irrelevant, and perhaps may be found both interesting and useful.

The Egyptians have been particularly distinguished for ingenious and diversified contrivances to elevate water from a low to a higher level, with the view of promoting vegetation, and to subserve the purposes of agriculture. To effect such an object, being essential to the subsistence of its inhabitants, their efforts to conduct and distribute that of the Nile, over the country, were astonishingly great. Solely for this end, they constructed canals in various directions, several of them extending the length of sixty, ninety, or even one hundred miles. The number of these works for receiving water during the inundations, and distributing it to a great distance, is said to have amounted to eighty. The grand cavities, called the Lakes of Moeris, Behira, and Mareotis, are deemed to be vast reservoirs, excavated for containing the

superabundance, which was afterwards to be employed for irrigating the plains in their vicinity. The means of conveying it over the mounds and high lands consisted of a series of buckets connected together by chains, and raised by the assistance of a wheel, when on their arriving at, and in passing over, the summit, each bucket successively discharged its contents. The invention of this machine is ascribed to the Egyptians, and oxen are sometimes employed to work it. Besides, as the power of one animal is sufficient for turning it, the watering of a large field can be effected by the labour of a single ox. It has been conjectured, that whilst Archimedes was in Egypt, the inspection of this useful device suggested to him the idea of his ingenious screw for raising water, which, at the present time, is very seldom used.

Savary observes that, "at the entrance to Old Cairo, stands an hexagonal building, each side of which is eighty feet wide, and one hundred feet high. Oxen mount up a very gentle ascent, and turn a wheel which raises water to the summit of this building:—five basins receive the water, whence it flows into an aqueduct, sustained by 300 arches for conveying it into a reservoir; but from the latter, other oxen, and another machine raise it to the palace of the Pacha. The Arabs constructed this work according to the plan of that described by Strabo, and of which the remains are visible, between the citadel of Babylon and the Nile. Strabo describes "the mountain as having a gentle descent from the fortress to the banks of the Nile, and 150 slaves continually employed in raising water thither, by means of wheels and screws."*

The same interesting traveller likewise relates, that

* *Travels in Egypt.*

"all the towns at a little distance from the Nile, are surrounded by spacious ponds, for the convenience of the inhabitants and agriculture. Aqueducts conveyed water to the tops of hills, where immense cisterns were hewn in the rocks to receive it, and whence it afterwards flowed among deserts, which the Egyptians transformed into fertile fields. Near to Babain are the ruins of an aqueduct running towards Lybia; it bears the majestic character of the works of this people; works not less miraculous, and certainly more useful than the pyramids or colossal figures of Thebais. They prevented the ravages of the high inundations, and supplied the defects of the low ones—thus conducing to the sustenance of millions of inhabitants.

It appears that "the castle of Cairo contains a curious well, sunk in the rock to the depth of 280 feet, and having a circumference of 42 feet. It consists of two excavations that are not perpendicular to each other. A stair-case, with a very gentle descent is carried round, but the partition, which separates this from the well, although forming a part of the rock, is left only a few inches thick; it has windows at intervals, but as they are small, and some of them low, the light of candles is required when persons descend. At that part of the well where its direction changes, there is a level space with a reservoir, and oxen, by turning a machine, draw the water from the bottom of the well. The water filters through the sand from the Nile, and being impregnated in its passage by salt and nitre, it has a brackish taste."*

At a small village near to Heliopolis is a fresh water-spring, said to be the only one in Egypt; and though presumed to be supplied by water filtered from the Nile,

* *Savary.*

the strata through which it passes, seems not to have the nitrous quality so common in the country. Its peculiarity has occasioned it to be an object of veneration, both by Christians and Mahometans, who alike visit it, and with great devotion drink its water. Tradition has also lent its aid to give it celebrity, by representing it as the fountain where the virgin bathed the child Jesus, when the Holy Family fled to Egypt in order to avoid the cruel mandate of Herod. An account has lately appeared, stating that a fresh water-spring has been discovered in the desert.

Another nation, alike celebrated for its antiquity as well as skill, in many of the useful arts of life, has devised several machines for the same purposes as those of Egypt; and though resembling them in some points, in others they are evidently inferior. The various productions of the Chinese afford striking and incontestable proofs, not only of their ingenuity, but that improvement marked the career of their exertions in former times, uniformly stationary as their efforts may have been at a later era. Some of their contrivances for raising water also present a remarkable contrast to the methods generally practised by Europeans, to economize human labour.

One of the Chinese modes of raising water is the following:—Two men stand opposite to each other on planks, that are fixed so as to project over the side of a river, and each holds the end of a cord, to the middle of which a basket is attached. This they swing to and fro, till it requires such a velocity as will assist them in throwing water into a reservoir, formed near the bank of the river; and thence it flows, by small channels, wherever it may be wanted. Another method consists in the erection of an upright post, on which is placed a long pole, in such a manner as to divide it into two unequal parts,

and it also works both vertically and horizontally on a pivot. To the end of the shortest part a large bucket is suspended, and lowered into a river to be filled, when, by the long arm of the lever, it can be easily raised, and turned towards the reservoir, where the contents of the bucket are emptied.

The Chinese chain-pump resembles that of the Egyptians, and motion is given to it in the same manner as the English tread-mill. It is formed by constructing a long wooden trough, placed in a sloping direction, and extending from the bed of a river to the summit of the elevated ground near its bank, where the reservoir is formed to receive the water. The inside of the trough is divided along the middle, by a board running edgewise through its whole length; and into these channels, square flat boards are exactly fitted in a regular series, being also connected together, at certain distances by a chain, which passes over rollers or wheels fixed at each end of the trough. The square boards are called lifters, because when the machine works, they force up the trunk a volume of water equal to their respective dimensions. That part of the machine which furnishes the means of applying the power for working it, consists of two upright wooden posts, having a strong horizontal pole connecting them together at their upper ends. About three or four feet below this cross piece, is placed a large wooden roller, over which the chain and lifters pass; and to this roller are fixed circular ranges of wooden arms, projecting from it, in the shape of the letter T; the cross pieces of these for the feet to rest upon, being made round and smooth. When thus completed, a rotatory motion is effected, by men treading upon the projecting arms attached to the roller, whilst they support themselves by holding the horizontal bar that connects the

two upright posts, and hence a continued stream of water is elevated. The quantity raised is proportionate to the size of the machine, and the power employed, for they are constructed of different dimensions, according to the purposes for which they may be wanted. The Chinese use them for raising water into reservoirs out of rivers or canals, or transferring it from one pond into another, and they also apply it to the purpose of draining grounds. Machines of this kind are sometimes constructed with a vertical cog-wheel affixed to the axis of the roller, and a large horizontal wheel connected with it, so that a buffalo, or other animal may be employed to work them. But those of a small size are very common, and are worked by a handle and crank, like that fixed to the common grinding stone;—such a portable contrivance being deemed as necessary and useful by the peasants of China, as the common spade is to those of some other countries.*

Another hydraulic machine, already alluded to, as attributable to the inventive genius of Archimedes, is the cochlion or screw. This contrivance consists of a leather, or metal pipe, folded spirally round an inclined cylinder, having the lower end of its axis adapted to work in a socket, with its upper end inserted in a groove, and a handle likewise attached for the purpose of turning it. Both ends of the pipe are left open, and the lower being placed in a well, cistern, or river, below the surface of the water, by turning the spindle, the revolving motion occasions the water to ascend, and flow out at the upper end into the reservoir constructed to receive it. The machine may be made with two or more pipes, folded parallel to each other; and if the inclination be consider-

* *Staunton's Embassy to China.*

able, it may be worked by a running stream; however, in this latter case, it is liable to be choked with weeds, or other substances, which diminish its power, and sometimes their removal is difficult.

The Persian water-wheel differs in its construction from the other machines heretofore described. It is fitted in a strong wooden frame, and when used upon a running stream, float-boards are affixed to the outside of its circular rim. From the inside of the rim strong iron rods project horizontally, and to each of these a square bucket is suspended by iron loops, so that in ascending and descending as the wheel revolves, all of them may hang perpendicularly, excepting those that dip into the water, and the one which may be at the highest point. Near to the top of the frame, and on the side opposite to that where the wheel moves, a trough projects so far as to intercept the buckets and tilt them, and thus each in succession pours its contents into the trough in passing over it. Besides, bent springs are fixed to that side of the bucket, which comes in contact with the trough, so as not only to break the force of their motion, but render their tilting effectual for discharging the water.

A water-wheel commonly used in China effects the same purpose as the Persian. It is formed wholly with bamboos; and short pieces of a large diameter having one end stopped up, are fixed, at regular distances, on the outside of the rim of the wheel. They are placed horizontally with such an angle as allows them to dip into the water by the revolving of the wheel, and thus being filled, they retain the water during their ascent, but pour it into a trough, adapted to receive it on the descending side.

The principle of Archimedes' screw machine has

sometimes been applied to water-wheels, by making the rim, axis, and spokes hollow, the latter having a curved shape, and each communicating with the axis by an orifice. By the revolution of wheels thus constructed, the spokes collect the water, and as they ascend it flows through the axis to escape at its apertures, and falls into a cistern which is placed below the axis. It will be evident that all the above machines may be worked by animal power, and are therefore applicable to a variety of useful purposes, according to situations and circumstances. Though the preceding descriptions of hydraulic machinery may convey a favourable view of the scientific attainments, and mechanical contrivances of different people, in various eras, yet, ingenious, useful, and effective as they may be for their object, how ineffably inferior, and limited in their application to the mighty, and almost indefinite power of the steam-engine!

Ample as may be the provision, beneficently afforded by the bounty of nature, for the wants of mankind, in some places the great difficulty of obtaining a sufficient quantity of clear soft water for common uses, has led to the invention and adoption of some very peculiar schemes to procure and preserve it. For this purpose capacious subterraneous cisterns have been constructed in various cities. At Jerusalem, these contrivances are commonly formed under the houses, as receptacles for the water produced by rain; and those discovered among the ruins of Alexandria, in Egypt, are remarkable for their magnitude. It is probable that they were filled when the Nile overflowed the country, and some of them rest on two or three tiers of arches, supported by large stone columns. The water was conveyed to them by the canal of Canopus, which had a passage under the walls near to Pompey's pillar, whence, by various subterranean

tunnels, it flowed to the highest parts of the city. As the cisterns occasionally require cleansing, they have perpendicular apertures resembling round wells, and holes are formed in the sides, at short distances, to enable workmen to descend. At present the water is drawn up from them by means of a windlass, and people sell it in leather bags that are carried on camels to the houses. It is stated that at Smyrna and in its vicinity, several arched vaults and tunnels exist, which are well built with hewn stone, for the purpose of collecting and preserving rain, the place being naturally deficient of such as is good for beverage and other domestic uses.

The city of Venice is extensively supplied with rain-water from the public and private cisterns, which have been constructed for the purpose of collecting and preserving it. One of the principal public receptacles of this description has its site in the court of the Ducal Palace, and the peculiarities of its formation entitle it to notice. In order to construct it the earth has been excavated to the depth of nearly twenty-four feet—the bottom resembling a parabola of six or seven feet radius. The centre has a well, formed with mason-work, the stones of which, at the lower part, are placed together without mortar; but the remaining part of the cistern, around the well, is filled with sand. In the middle of this bed of sand, and concentric to the external line of the paraboloid, a small tunnel is constructed, having several apertures in its upper part; and the whole surface of the cistern, excepting the well, is covered with a pavement, corresponding with that of the court. As proper channels and apertures are constructed for the purpose, whenever rain occurs, the water that falls from the roofs of the houses, flows to the channels connected with the reservoir, and penetrating the sand,

passes along the tunnels to the lower part of the well, whence it rises in a transparent state. Thus every morning the well becomes full; and though the level of the water may occasionally vary according to the quantity drawn off, yet the reservoir continually furnishes it clear and fresh. By such means a considerable supply of good soft water is generally afforded to the inhabitants of Venice, except in very dry seasons. A large quantity is also obtained from the river Brenta, whence it is conveyed in barrels to the city by barges employed for the specific object. Some of the vessels are also fitted up with large cisterns, having pumps to discharge their contents.

The circumstance of collecting rain-water in cities, has given rise to some interesting remarks by Professor Leslie, who states, that "it has been computed the quantity of rain which falls annually over any city, if carefully collected and deposited to purify in cisterns, would be sufficient for the supply of the inhabitants, at least in all the essential domestic and culinary purposes." He also observes, that "the roof of a lofty house at Paris, containing on an average, twenty-five lodgers, might deliver annually 1800 cubic feet of rain-water, which would furnish each individual, daily, the fifth part of a cubic foot, or about thirteen pounds avoirdupois;—rather a scanty portion, to be sure, according to our modern ideas of comfort."* The following observations of the same writer are also important from their applicability to practice:—

"The vast energy which capillary action derives from the combination of numerous and very minute orifices, is illustrated and confirmed in a striking manner, by an

* *Leslie's Elements of Natural Philosophy*, p. 409.

application of the *Atmometer*, an instrument designed to measure with accuracy the quantity of evaporation in a given time. A thin ball of porous earthenware, about three inches in diameter, is cemented by its narrow neck to a glass tube, a quarter of an inch wide and three feet long. The whole cavity of the ball, and of the tube being now filled with recently distilled water, is inverted, and set upright in a small cistern of quicksilver. The surface of the ball soon loses its glistening humid appearance, but the evaporation continues just as at first, and the water rises gradually in the tube to supply the incessant consumption. The quicksilver follows the water, and mounts with greater or less rapidity, according to the slenderness of the tube, and the dryness of the encircling air of the room, from two to five or even eight inches every day. This ascension is nearly uniform, till the quicksilver has gained an elevation of perhaps twenty inches. The water having then its atmospheric pressure lessened, yields a portion of its contained air, which, collecting within the ball into a diffuse vapour, checks by its elasticity, in some degree, the rise of the water and the quicksilver in the tube. However, this ponderous fluid still continues to mount, though more slowly than before; and, in the space perhaps of ten days, it stands scarcely an inch below the level of the barometric column. In this situation it remains, till the whole of the water within the ball has evaporated, and the pores are again opened to the admission of the external air. When this event takes place, the mercury in the tube suddenly falls down into its cistern.

"The attraction of the very fine pores of the Atmometer, is thus more than sufficient to support a load of mercury equal to that of 400 inches of water. Those

pores are smaller than the ten thousandth part of an inch.

"We may hence conceive the rise of water through successive strata of gravel, coarse sand, fine sand, loam, and even clay. If the gravel were divided into spaces of the hundredth part of an inch, the water would ascend more than four inches; but supposing the particles of the coarse sand to be the five hundredth part of an inch, it would mount through a bed of sixteen inches of this material. Assuming the fine sand to have interstices of the two thousandth five hundredth part of an inch, the midity would be drawn up through a new stratum of seven feet thick; and if the pores of the loam were only the ten thousandth part of an inch, it would gain the farther height of twenty-five feet and a half through the soft mass. The clay would retain the moisture at a greater altitude, and in this way each stratum of finer pulverization might successively raise the moisture still higher. But, though the extreme subdivision of the particles may carry the elevation almost to an unlimited extent, yet will it also retard the insinuation of the water. Hence, the use of clay in *puddling*, or choking up the grosser pores, which might favour the efflux from a a dam."*

If such be naturally the force of capillary action, does not the circumstance suggest how extensively useful its application might be made to affect that most desirable object—the purifying of water previous to its being permitted to go from water-works into the cisterns for domestic purposes? Would it not be practicable so to combine this potent principle with that of pressure, as to

* Leslie, p. 361-4.

render the reservoirs at such establishments efficacious filters, by some peculiar adaptations in their construction? The reservoir at the Ducal Palace of Venice affords an instance of the kind; for its centre consists of a large circular well, which is formed with a bed of sand surrounding it, so that all the water passes through, and consequently flows in a pellucid state to the fountain, whence the inhabitants obtain it. In those places where the supply of water is usually procured from rivers constantly in motion, the adoption of such a plan would prove highly advantageous, and such sources would generally furnish the means of having a large head-pressure of water to facilitate the attainment of its object. This circumstance may not be unworthy of the consideration of engineers, in the arrangement of any new works, or the improvement of others that have been heretofore constructed.

The exigencies and enjoyments of mankind have frequently occupied the serious attention of philosophical observers, who, after nicely scrutinizing the varied operations of nature, have endeavoured to deduce rational and useful conclusions. One of their statements is remarkable, and probably resulted from a rigid examination and comparison of facts: these have led to the inference that the average quantity of water supplied by rain, in some climates and situations, has a relative proportion to the absolute wants of the inhabitants of a populous city. It would, however, be indiscreet to rely solely upon such a casual source, which might occasionally expose them to much inconvenience, from the time of rain falling, as well as its quantity, being both variable and uncertain. Hence, in many cases, a deficiency might occur, when plenty was most desirable; and the probability of such contingencies, imperatively urge to the adoption of

methods, which may be certainly effective for attaining so important an object, as a plentiful supply of salubrious water to a great population, whatever difference may happen in the state of the seasons.

The site of Lisbon, as well as the ground in its vicinity, consists chiefly of limestone and basalt, which render it necessary to obtain good water, at about three leagues distance, for the beverage, and other uses of the inhabitants. The source consists of several springs that are near to the village of Bellas, and their produce is conveyed to Lisbon by an aqueduct, constructed of a kind of white marble, and finished in 1738. In some parts its course has been excavated through hills; but near to Lisbon it is carried over a deep valley, for a length of 2400 feet, by means of several bold arches, of which the largest has a height of about 250 feet, by a breadth of 115. The arches being pointed have an interesting aspect, particularly when viewed from below, the interior of the spacious vaults being not only majestic in appearance, but reverberating every sound. The water flows through a stone tunnel, or covered arch-way, about eight feet wide, formed in the middle of the structure; and on each side there is a foot-path, with a parapet wall, having a sufficient width for two persons to walk. The aqueduct enters the town, on its northern side, at a place called da Amoreira, where it branches into several others, in order to supply the different fountains, from which the inhabitants are supplied. Persons, denominated *gallegos*, obtain a subsistence by selling the water, which they procure at the fountains in small barrels, and afterwards cry it through the streets.

Formerly Algiers had neither wells nor fountains, but considerable improvements, in this respect, have been introduced into that once renowned seat of barbarism

and piracy. It is at present supplied with excellent water, from the mountains in its vicinity, by two aqueducts, which have been constructed to convey it to various fountains, erected for the purpose of its distribution amongst the inhabitants.

The city of Valetta, in the island of Malta, derives its supply of water from a source near to Bosquetta; and an aqueduct, consisting of some thousands of arches, conveys it to the inhabitants. The execution of this immense work is said to have been effected, at the private expense of one of the Grand Masters.

The inhabitants of nearly all the capitals, as well as the principal cities and towns on the continent of Europe, and other parts of the world, are, however, supplied with water, either from contiguous rivers, or by wells formed for the purpose. The sale of this necessary article of human subsistence, also furnishes employment, in some countries, to a great number of people, who earn, by such an occupation, a miserable livelihood. Such was formerly the case in many, and, to a certain degree, is still so in some, of the large towns even of this country. But the practice has evidently prevailed from an immemorial period; for "hewers of wood and drawers of water," is a proverbial expression of the highest antiquity, and seems to have been generally employed to designate that painful and toilsome labour, which obtained but trivial remuneration, and was deemed nearly, if not quite, equivalent to positive slavery. How striking the contrast, how inestimably superior, in every point of view, the methods introduced by science and art, to afford the abundant supply of water to London, Edinburgh, and other great cities in Britain!

CHAPTER X.

Methods employed by the ancient Romans to obtain clear water. Magnificent structures of the opulent. Baths of Dioclesian, Antoninus Caracalla, and Titus. Sumptuous baths of private individuals. First aqueduct constructed by Appius Claudius. Roman custom of bathing on different occasions. Gymnastic exercises connected with the baths: temperature of the water various. Use of oils and perfumes. Reflections of Pliny. Number of aqueducts increased by Agrippa. Frontinus appointed to the office of Ædile: his meritorious conduct. Large quantity of water supplied to Rome. Cloacæ.

The multitudes of civilized people congregating in great cities, have not only the same positive wants as the rude inhabitants of the woods and the wilds, but their habits and tastes are also connected with a diversity of conveniences and comforts, requiring a plentiful supply of water. Hence, many practices, introduced during the progress of refinement and luxury, have rendered schemes for readily affording a large quantity, important objects for exercising genius and stimulating industry. Probably a more appropriate and striking illustration of this statement cannot be adduced than that of ancient Rome, where the public and private pleasures or amusements of its inhabitants, or attention to health and cleanliness, led them to construct very stupendous works, to supply abundance of water for their various purposes. Though the ravages of time, and the violence of barbarians, have either injured or destroyed many of their elaborate and magnificent structures, yet the whole of some, and parts of others, still remain to gratify curiosity,

and excite admiration; so that susceptible and cultivated man comtemplates such noble and useful contrivances with the most lively emotions, as extraordinary monuments of human ingenuity and labour. To the philosophical observer they prove fertile sources of instruction, by exhibiting the state of science, and the excellence attained in architecture and several other arts, at the era of their construction, as well as by vividly and forcibly pourtraying the voluptuous propensities, habits, and enjoyments, which formerly prevailed amongst the opulent, ambitious, and haughty residents of "the eternal city."

During that splendid and extraordinary career pursued by the Romans, till they attained the acmé of their glory, the wealthy and powerful amongst them not only acquired a taste for the most luxurious pleasures, but vied with each other in the erection of magnificent edifices, suitable for every purpose conducive to their enjoyment. The diversified productions of genius and skill were eagerly and incessantly sought to augment the number and intensity of their gratifications. Hence, originated the construction of extensive galleries, supported by marble columns and noble arches, covered and embellished with similar materials. The most elegant and transcendant works of art, consisting of statues, paintings, and basso relievos, adorned these superb structures, which sometimes contained the plunder of cities, and even that of whole provinces. Indeed, their historians and orators represent the military commanders, and civil governors, as alike practising the greatest enormities to obtain possession of the master-pieces of Grecian sculptors, painters, and other artists. Even Marcellus, Scipio, and Paulus Æmilius, although so much eulogized for other achievements, indulged in the most audacious rapacity, by seizing

whatever they found remarkable for excellence, in the different countries where their power was exercised.

The strongest colouring is employed by Livy, to depict the conduct of those celebrated men; and, among other facts, he affirms that Marcellus conveyed to Rome the statues and pictures which abounded at Syracuse, but he designates them as "the spoils of enemies, and acquired by the right of conquest." Though this circumstance first occasioned the Romans to admire the finished productions of the most eminent for genius, taste, and skill, amongst Grecian artists, yet to the same cause may be ascribed that unprincipled cupidity, which afterwards characterized their proceedings in pillaging the houses of wealthy individuals, as well as the temples of the gods, and even some of those in the city of Rome, which had formerly been adorned by the efforts of Marcellus!* In the oration against Verres, Cicero charged him with having committed similar excesses whilst officiating as Prætor, in Sicily, by stripping cities, temples, and private houses, of all their valuable statues, pictures, marbles, and bronzes of every kind. But these nefarious spoliations were commonly practised by the principal officers; and such depredations furnished their galleries at Rome, and their villas in the country, with the finest works of different nations. Indeed, there seemed to be a rivalry for the possession of the greatest number and variety of pre-eminent, sumptuous, and precious ornaments, regardless of the ignoble means employed to obtain them.

Great, however, as was the propensity to indulge in gorgeous display and voluptuous extravagance, in many instances, the wealthy Romans devoted their superb and highly embellished galleries to different useful and

* Livii *Hist.* lib. xxv. cap. 40.

laudable purposes. Some of their saloons being the receptacles of libraries, as well as the finest works of sculptors and other artists, persons who were eminent for their mental endowments, or moral excellence, usually resorted to and assembled in them, to participate in the rational delights of social intercourse, and the improvement resulting from literary conversation. In such places Cicero, and Virgil, and Horace, luxuriated amongst intellectual entertainments; for here philosophers disputed, orators declaimed, and votaries of the muses recited their effusions to persons of both sexes and different ages, who indiscriminately mingled together in friendly communion. In these assemblages sages also imparted the fruits of their experience, and thence the aspiring youth of Rome imbibed lessons of wisdom and virtue, animating them to perform magnanimous deeds, for the glory of their country, and to secure for themselves an imperishable name.

But amongst the superb structures of the Romans, the very extensive baths, or bagnios, hold a prominent place, and probably afford the most striking instances of their luxurious taste and habits. A considerable portion of these, constructed for Dioclesian, Antoninus Caracalla, and Titus, still remain to gratify the curiosity of the moderns;* and these vestiges consist of numerous apartments, abounding with ornaments. In the construction of the different parts, the finest kinds of marble are employed; and whether regarded for magnitude or magnificence, both must be deemed extraordinary. Lofty arches, supported by stately columns, form many of their interior divisions. The roofs are also curiously vaulted;

* The baths of Dioclesian occupied a space of more than 1000 yards in length, with a similar breadth; and those of Caracalla would accommodate about 3600 persons.

and the walls were originally decorated with a diversity of beautiful designs, finely executed in relief. Indeed, if credence be due to early writers, extravagance and fastidiousness were almost unlimited in the formation of these establishments. Seneca complained that some of his countrymen disdained to put their feet in baths that were not laid with precious stones;—a statement apparently countenanced by the elder Pliny, who expressed a wish that good old Fabricius could witness the conduct of his posterity, because the women required the seats of their baths to be made of solid silver;* besides, it is stated that some of the females actually bathed in silver cisterns, into which the water flowed through silver pipes. Seneca thus dilates upon their luxurious refinement and costly indulgences.—"A man thinks himself poor and mean unless the walls are decorated with large and precious embossments—unless Alexandrian marble be pointed and inlaid with Numidian rough cast—unless a rich and curiously variegated plastering be spread upon them in picturesque—unless the roof be covered with glass work—unless the Thacian stone, once reckoned a scarce and curious ornament even in some temples, now compass about the basins in which we bathe our bodies, when enfeebled with fatigue at some trifling sport—in short, unless the water be conveyed by a silver spout."†

The enumeration of a few facts relating to the occupations, customs, and amusements of the Romans, in different eras, will show the importance of their aqueducts, which have so often been the theme of panegyric. In the early days of the republic, bathing was practised only on particular occasions; such as their fairs, or public assemblies for political and other purposes, which

* Plinii *Nat. Hist.* lib. xxxiii. cap. 12.

† Senecæ Epist. 86.

occurred at intervals of several days, when, as necessity or pleasure might prompt, the Tiber and other rivers, or pools, served for baths. At that period no artificial contrivances of the kind had been constructed; and the first instance of water being conveyed to Rome from a distant place, occurred in the year 422 from the building of the city, when Appius Claudius, the censor, directed the formation of the aqueduct, which was thence called *Appia Claudia*. Previous to the construction of this useful work, the inhabitants generally procured the supply of water for all their purposes, either from the Tiber, or the wells and springs in the vicinity of Rome.

The method of conveying water to Rome, by an aqueduct, proved so advantageous as soon to occasion the number to be increased; and by thus facilitating the means of obtaining a large supply, the opulent were induced to construct baths, and *thermæ*, or bagnios, for their own accommodation. Originally, the latter structures were remarkable for simplicity, and formed a striking contrast to the sumptuous edifices erected at a subsequent period; but in the progressive changes of manners among the Romans, frequent and daily bathing became one of their practices and amusements, which therefore occasioned the construction of many private and public baths. The public establishments of this kind were open at certain stated hours of the day, when, at the sound of an instrument resembling a bell, every citizen, without any distinction of rank, might avail himself of the opportunity of enjoying the pleasure and advantage of using them. Generally, the attendance was assiduous and regular, from the habit of bathing being held in the highest estimation; so that those who abstained, usually exposed themselves to reproach, as lazy or negligent. It may likewise be observed, that

their use constituted one of the principal recommendations of their physicians, as a remedy for various diseases.

Gradually, however, was introduced the custom of connecting with the baths, the buildings appropriated to the gymnastic games; and, probably, this circumstance may be one reason for the great increase of their magnitude, as well as some addition to their number. The assemblages of people on such occasions, and the violent exercises of the numerous individuals engaged in those amusements, rendered capacious baths not only desirable, but also indispensable. Hence, their amazing amplitude induced one of their historians to compare them to provinces, rather than any other objects, from the great number of their spacious rooms, extensive galleries, porticos, terraces, gardens containing ponds, with streams of water running through them; and also having various kinds of promenades, planted with trees, so as to resemble woods.

The private baths of the opulent Romans, astonished alike by their sumptuousness and magnitude, as well as their elaborate and costly decorations. Edifices of this kind usually consisted of an assemblage of lofty and spacious apartments, with roofs supported by beautiful marble pillars, and the pavement formed of elegant mosaic work. The walls were generally covered with the finest marble, often of different kinds, and at the same time richly adorned with the most excellent sculptures and paintings, that the ingenuity or skill of the best artists could produce. Even the basins for the water were formed either with marble, porphyry, or oriental granite: some of them being permanently fixed, whilst others were made to be suspended, so that the pleasure of bathing might be increased by a gentle and easy rocking motion. Different apartments also contained baths, of

which the temperature could be varied and adapted to the taste and desires of those who frequented them; and for this purpose large brick stoves communicated heat to several at the same time, so as to afford the accommodation of either a tepid, hot, or steam bath.

Another practice that commonly prevailed among the Romans, evinces the utility of these contrivances. Previous to taking that repast, which in modern times is called dinner, it was their custom to bathe; and this probably may have been the chief reason for the principal baths being formed contiguous to the dining-room. As the splendid mansions of the wealthy usually contained large and commodious basins, in which persons could enjoy the pleasure and exercise of swimming, on occasions of social festivities, the guests were offered the use of the baths before participating of the feast.

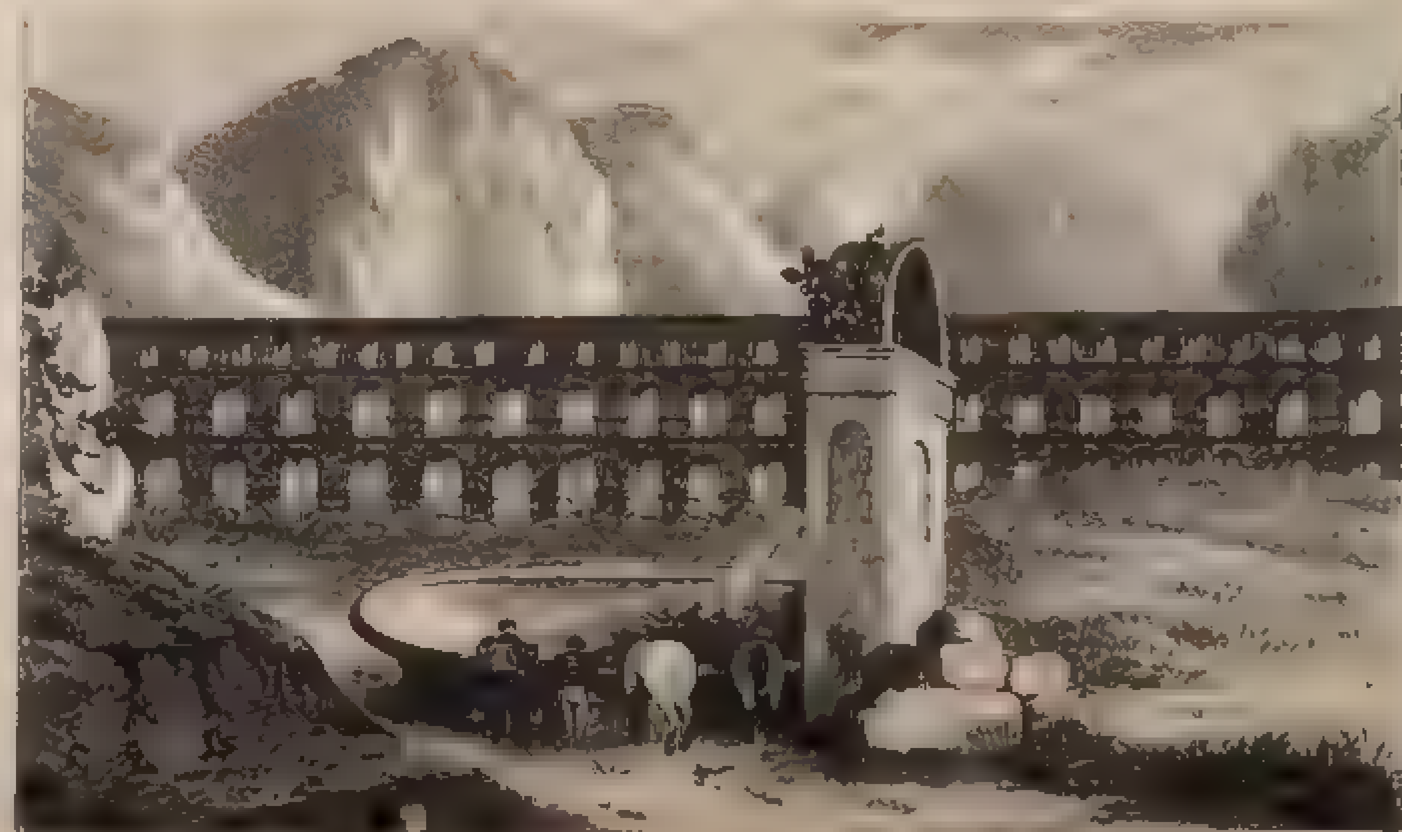
The Romans generally began their bathing with hot water, and concluded with cold, when they afterwards underwent the operation of rubbing with oils and perfumes. Persons of both sexes equally indulged in these refreshing and healthful enjoyments. At one period the public baths were indiscriminately used; but as such promiscuous bathing gradually became offensive, by its diminishing or destroying the delicacy of moral feeling, and a due regard for decorum, it was consequently prohibited, when each sex had separate baths provided for their respective use. Male and female slaves attended the public baths to perform different services; and these people had designations according to their several employments: some heated the baths, others had the care of the clothes of those who bathed; whilst another class was engaged in rubbing the bathers with oils and perfumes. Considerable revenues were applied to the maintenance of these establishments; and officers, appointed by the

government, superintended them. It may not be irrelevant to remark that, although no distinction of rank, or quality precluded admission to them, and whatever disregard of delicacy or decency might occasionally have occurred, at one time it was considered unbecoming for a father to bathe with his own sons, or sons in law, when they had arrived at the age of puberty. This fact may appear to be singular, but it serves to illustrate the modifications of manners and moral sentiment, in different ages, even among the people of the same nation.

The reflections of Pliny concerning the aqueducts for supplying Rome, evince the admiration excited by them at the period of his writing. "If any person," he observes, "shall very attentively consider the abundance of water conveyed to the public, for baths, fish-ponds, private houses, fountains, gardens, villas,—conducted over arches of considerable extent,—through mountains perforated for the purpose, and even valleys filled up, he will be disposed to acknowledge that nothing was ever more wonderful in the world."* The first of these grand structures mentioned in a former page as being formed during the censorship of Appius Claudius, and thence denominated *Appia Claudia*, had its source in the district of *Tusculum*, where, after making a circuitous course of about 800 paces, it proceeded through a deep subterraneous channel, more than eleven miles in length, and entering the city at the Appian Way, delivered the greater portion of its water in the *Campus Martius*.

The formation of another aqueduct, the *Aqua Martia*, originated with Quintus Martius. It began at a spring, thirty-three miles from Rome, and having a circuitous channel along the surface of the ground for three miles, it

* Plinii, *Nat. Hist.* lib. xxxvi. cap. 15.



Part of Aqua Martia with a Castellum

Section of a Double Roman Aqueduct

then entered a tunnel sixteen feet in diameter, whence it continued for thirty-eight miles; having also in its course a series of nearly 7000 arcades, with an elevation of seventy feet. In various parts of this extensive aqueduct deep cisterns were formed, for the purpose of receiving the sediment deposited by the water; and at certain distances, the upper parts had apertures for the escape of air, that might be collected in the conduit. The water supplied from this source is represented to be remarkable for its green colour; and Pliny, in his *Natural History*, particularly celebrates its excellence, for when treating of the qualities of waters, he thus eulogizes it:—"Among the blessings conferred upon the city by the bounty of the gods is the water of the *Martia*; the clearest of all the waters in the world, and distinguished for coolness and salubrity." *

From the obvious utility of these important works to the inhabitants of Rome, different persons were induced to construct others of a similar kind; and hence, at successive periods, their number was greatly augmented. During the reign of Augustus, some of the aqueducts, which had long been erected, being found in a decayed condition, Agrippa, who then held the office of Ædile, or principal curator of the public works, not only repaired their dilapidations, but also constructed a new one. All the aqueducts being formed with a slight descent, the water always flowed in a gentle current; and through nearly the whole extent of the channels they were covered.

Among the noble works constructed by Agrippa was the aqueduct called *Aqua Virginia*, which began at a copious spring in the middle of a marsh eight miles distant from Rome, but its winding channel extended the

* Plinii, *Nat. Hist.* lib. xxxi. cap. 3.

length of about twelve miles, passing in its course through a tunnel 800 paces long. According to the statement of Pliny, the aqueducts at this period were rendered eminently subservient to the improvement and embellishment of Rome; for with the view of facilitating the use of the waters, by making them generally accessible, he states that Agrippa, "in the course of one year actually formed seventy pools; 105 fountains, and 130 reservoirs, besides adorning all these works with several hundreds of marble statues and columns."* It is likewise remarkable that the *Aqua Julia* and *Aqua Tepula* conveyed their water by the same course as the *Aqua Marcia*, their respective channels resting upon arcades erected one above the other. The latter was the lowest, the *Aqua Tepula* formed the second, and the *Aqua Julia* the highest. Though thus combined, they were evidently built at different periods, and the still subsisting ruins of this extraordinary structure, indicate its pristine grandeur.

But the most accurate and circumstantial information, relative to the aqueducts, has been conveyed by Sextus Julius Frontinus, to whom the Emperor Nerva confided their superintendence. Endued with superior talents, and a cultivated understanding, his chief aim seems to have been the performance of the duties of such an office with fidelity, diligence, and propriety; for on his entrance upon its important functions, he anxiously and sedulously endeavoured to acquire the knowledge requiste for enabling him to fulfil them effectively and satisfactorily. To the laudable disposition, and meritorious exertions of this accomplished man, the public are indebted for a treatise *Concerning the Aqueducts of the City of Rome*, in the preface to which, he affirms it to be "disgraceful for a man

* Plinii, *Nat. Hist.* lib. xxxvi. cap. 15.

of sense, to depend upon the instruction of subalterns for directing him in the performance of his duty." How noble and magnanimous the sentiment! And how worthy of imitation by those who may occupy momentous and responsible stations in society!

According to the statement of Frontinus, the supply of Rome, prior to his time, was effected by nine great aqueducts; but during the reign of Nerva, five more were constructed, and under successive emperors the number appears to have increased to twenty. Besides those already noticed, two of the most remarkable of these structures were the *Old* and *New Anio*; and these aqueducts derived their names from being the means of conveying the water of that river to Rome. The former began its course above the Tiber, near the thirtieth mile-stone from Rome; but the sinuosities of its channel rendered the length of it nearly forty-three miles. The latter was, however, constructed on a higher level, with its course along the surface of the earth for 7543 paces, when it entered a subterranean tunnel of the length of 54,267 paces. This structure was formed during the reign of Nero, and it contained more than 600 arches, some of which exceed 100 feet in height.

The *Aqua Claudia*, another of these stupendous and magnificent works, was begun in the time of Caius Cæsar Caligula, and completed during the reign of his successor Claudius. This extraordinary edifice was built with hewn stone; it commenced at the distance of about thirty-eight miles from Rome, and its elevation was so great as to adapt it for supplying all the hills of the city, even the highest. It had a subterraneous channel for thirty-six miles and a quarter, afterwards running along the surface of the ground ten miles and three quarters in length, it passed through a vaulted tunnel three miles, besides being

continued for the extent of seven miles on arcades, some of them very lofty. This grand and extensive aqueduct still continues to afford its advantages to the inhabitants of the modern city; and from the great excellence of the water afforded by this source, it has obtained the appellation *Aqua Felice*. Our moral didactic poet, John Dyer, while residing in Italy, contemplated these magnificent works, and has given the following felicitous description of them:—

"The radiant aqueducts
Turn their innumerable arches o'er
The spacious desert, brightening in the sun,
Proud and more proud in the august approach:
High o'er irriguous vales, and woods, and towns,
Glide the soft whispering waters in the wind,
And here united pour their silver streams,
Among the figured rocks, in murmuring falls,
Musical ever." *The Ruins of Rome.*

Limpid and salubrious water seems to have been generally held in the highest estimation by the ancient Romans, from their sparing neither labour nor expense to obtain it. A circumstance strikingly evincing their solicitude to have this fluid pure and transparent, was that of actually procuring it from the distance of thirty miles beyond Tivoli, though the cascade at that place is more elevated than the site of the city of Rome. On this subject Professor Leslie observes that, "Trajan showed particular solicitude in improving the aqueducts. Those works were executed in the boldest manner; nothing could resist the skill and enterprise of the Romans; they drained whole lakes, drove mines through mountains, and raised up the level of valleys by accumulated arcades. The water was kept cool by covering it with vaults, which were often so spacious, that according to Procopius, who wrote in the time of Belisarius, a man on horseback could ride through

them. So abundant indeed was the supply as to induce Strabo to say that whole rivers flowed through the streets of Rome."* It has been stated that the number of reservoirs was more than 1300; and that the quantity of water daily amounted to 500,000 hogsheads.

"The great abundance of water which, at one period, was conveyed to Rome, has often excited admiration and astonishment. From Frontinus's statement it appears that the nine aqueducts constructed prior to his appointment to be curator, daily supplied 14,018 *quinaria* of water, which quantity is equivalent to 27,743,100 cubic feet. But after the construction of various others, and the whole were in full operation, the supply probably amounted to 50,000,000 cubic feet; if therefore the population of Rome, at that time consisted of 1,000,000, fifty cubic feet would be the proportionate quantity for each inhabitant. According to an estimate of M. Prony, three of the aqueducts which at present supply Rome, the *Aqua Felice*, *Juliana*, and *Paulina*, with some other sources, deliver every day, 5,305,000 cubic feet of water, which being divided by the number of its present population—130,000—averages about forty cubic feet for each inhabitant; making the proportion only one-fifth less than the supply in the most splendid and populous era of ancient Rome."

Professor Leslie remarks that "such a profusion altogether transcends our conceptions. The supply of London in the year 1790 was only 2,626,560 cubic feet daily; and even now when the rivalship of the several Water Companies has almost deluged the streets, it amounts only to 3,888,000 cubic feet. This quantity is abundantly sufficient for all the wants of a luxurious mass of inhabitants, equal certainly to the population of

* *Elem. Nat. Phil.* p. 418.

ancient Rome, where the consumption, however, was fourteen times greater. How paltry then appears the actual supply of Paris, amounting only to 293,604 cubic feet of water a day! It affords scarcely half a cubic foot, or thirty pounds avoirdupoise, to each inhabitant, in a population of upwards of 600,000."*

As a sequel to this narrative, perhaps, it may not be uninteresting to notice the *Cloacæ*, or sewers of Rome. Pliny designates them as "the greatest of all the works;" and according to his description "they were constructed by cutting through, and forming enormous tunnels in the hills on which the city was built, apparently suspending it to a considerable extent, so that vessels might sail under it. During the time that Agrippa was Ædile, he contrived that seven different streams should unite in them, so that their collective force occasioned such a rapid current, as agitated and carried away every thing entering into them. Sometimes they received the superabundant water from the floods of the Tiber, when the meeting of the different streams produced furious contention, and by their commotion beat violently against their bottoms and sides. The ruins of buildings destroyed by fires, or other accidents, were likewise sometimes precipitated into and carried down their channels; besides earthquakes occasionally shook their foundations, without affecting their stability, which was such as to prevent their sustaining any serious injury through the long period of 800 years, which had elapsed from the time when *Tarquinius Priscus* first constructed them."† Such is the interesting account given by Pliny of the origin and use of these extraordinary structures, which consist of large arched

* *Elem. Nat. Phil.* p. 420. These remarks were written by the professor, in 1823.

† Plinii, *Nat. Hist.* lib. xxxvi. cap. 15.

galleries constructed in every direction under the city of Rome. The principal channel, called *Cloaca Maxima*, has a breadth of about sixteen feet, with a height of thirty, and all the others communicate with it. The bottoms, sides, and arches are formed with large blocks of stone, well and strongly connected together; and notwithstanding the weight of the buildings, ruins, and other things either incumbent upon, or forced down them, recent travellers represent that their solidity and good condition is still very remarkable, although choked up at one end through the neglect, laziness, or indifference of the present public functionaries of Rome.

> "Such the sewers huge,
> Whither the great Tarquinian genius dooms;
> Each wave impure; and proud with added rains,
> Hark! how the mighty billows lash their vaults,
> And thunder! how they heave the rocks in vain!
> Though now incessant time has rolled around
> A thousand winters o'er the changeful world,
> And yet a thousand since, the indignant floods
> Roar loud in their firm bounds, and dash and swell
> In vain, conveyed to Tiber's lowest wave." JOHN DYER.

CHAPTER XI.

Materials employed in the construction of the Roman Aqueducts. Variations in forming them. Knowledge of Hydrostatics displayed by the Romans. Lead and Earthern Pipes. Instruments used for taking levels. Modes of distributing and measuring Water. Magnitude and splendour of Antoninus Caracalla's Baths; adorned with fine Paintings and Sculptors. Extraordinary grandeur of those erected by Dioclesian: number of People employed in constructing them. Titus's Baths on the site previously occupied by the house and gardens of Mæcenas, and near the residences of Virgil and Horace. Great number of apartments in the Baths of Caracalla: their uses and conveniences. Methods of heating the Baths. Motives for constructing the great Roman works. Contrast of modern times.

Various circumstances concerned in the formation of the Roman aqueducts are deserving of observation;—for instance, the materials employed were different even in the same aqueduct; and in constructing an arch of the *Aqua Martia* there were used three kinds of stone, one reddish, another brown, and a third of an earthy colour. The *Aqua Claudia* was constructed with a beautiful hewn stone, whilst others were built with bricks and a strong cement, which so firmly united them as to render the work almost a solid mass. Moreover, the *Aqua Appia* differed from the others, by its having a peculiar construction of width, as it approached the point where the water was disembogued.

Although several of the Roman aqueducts might have been constructed in a straight line, yet it is remarkable that their contrivers adopted a sinuous course with numerous windings. Various plausible reasons have been sug-

gested for their preference of such a devious track; some presuming its chief object was to avoid the expense of erecting arcades of great height and solidity; whilst others have inferred that it solely had in view the preserving of a gentle and equable current for the water. The latter reason appears to be both plausible and cogent; for if the velocity had been considerable, the strong and impetuous motion of the water would have continually kept it in a turbid state, and consequently rendered it unsuitable for the beverage and other uses of the inhabitants. However, another important circumstance demanded peculiar attention and consideration; this was the prevention of injury to the aqueducts, from the constant attrition produced by the force and motion of a very quick current upon the bottoms and sides of their channels, for the repairing of such dilapidations would inevitably be attended with great inconvenience.

The eminent professor quoted in a former page, and who was alike distinguished for superior intellect, diligence of research, and diversity of attainments, has enumerated several circumstances illustrative of the scientific knowledge and mechanical skill of the ancient Romans. His detail is concise, but it conveys much curious information that may interest and gratify those, who may be desirous of learning what were the acquisitions of a people, so celebrated in the annals of the world, and whose various achievements will never cease to obtain the admiration of mankind.

"It is a prevailing opinion," observes Professor Leslie, "that the Romans, amidst all their magnificence, were *ignorant* * of the simplest elements of *Hydrostatics*, and

* A recent publication has the following remarkable passage—"*Ignorance of the principle by which liquids return to their level,*

therefore entirely unacquainted with the method of conducting and raising water by a train of pipes. Nothing, however, can be worse founded than this notion. The ancient writers, who either treat of the subject, or incidentally mention it, are clear and explicit in their remarks, while many vestiges of art still attest the accuracy of those statements. Pliny, the natural historian, lays down the main principle that "water will invariably rise to the height of its source:" *subit altitudinem exortus sui.* He subjoins that *leaden pipes* must be employed to carry water up to an eminence.* Palladius, in his treatise *De Re Rustica,* teaches how to find springs, by observing immediately before sun-rise in the month of August, the vapours which hover above particular spots; and having there dug a well, he directs the water to be conducted to the farm or villa, either by a channel constructed of masonry, or by means of pipes of lead, of wood, or even of earthenware.† He allows one foot in sixty, or in a hundred, for an uniform descent. But if the ground should afterwards rise, he says the conduits must be supported on piles, or arches, or the water must be inclosed in leaden pipes, when it will mount just to the level of its head.‡ But Palladius testifies his aversion to the use of lead as apt to become covered with ceruse, and thereby rendered unwholesome, or even poisonous. This consideration had no doubt served to restrain the general adoption of leaden pipes among the Romans. Still, however, we may infer from the allusions of the poets, that such pipes had come into very common use. They were

is shown in the construction of aqueducts by the ancients, for supplying water to towns!—*Lardner's Cyclopædia.*—Hydrostatics, p. 69. How does this assertion accord with Professor Leslie's authorities from ancient writers?

* Plinii, *Nat. Hist.* xxxvi. 7. † Palladii, ix. 11. ‡ *Ibid.*

not cast tubular as at present, but consisted of thin plates of lead bent up into the form of a cylinder, and soldered along the edge.* They must frequently have given way, therefore at this seam. Horace asks, if the water which threatens in the streets to burst its *lead*, be purer than the rivulet that trembles and murmurs as it flows.† Ovid compares the gusts of blood from the mortal wound which Pyramus, in the agony of despair, had inflicted upon himself, to the accidental rupture of a *leaden pipe*.‡ Statius speaks, no doubt with poetical exaggeration, of whole rivers being discharged by such conduits §

"Vitruvius describes the three principal modes of conveying water; but directs as the previous operation, to trace a level (*libramentum*) on the ground. This *libration* was performed by the *dioptron*, the *water-level*, or the *chorobates*. The dioptron seems to have been a sort of quadrant fitted with sights; the water-level consisted of a tube, probably of copper, five feet long, and an inch wide, turned up an inch and a half at both ends,

* "In the Physical Cabinet of the University of Edinburgh, is now deposited a specimen of ancient leaden pipe, lately brought from Rome, where it had been dug up among the ruins of the palace of the Cæsars. It bears an inscription in raised letters, intimating the name of the plumber, and the year of the reign of the Emperor Domitian. Though only sixteen inches long, and nine and a half in girth, it weighs twenty-two and a half pounds avoirdupoise; so that the lead must be very nearly half an inch thick. The pipe is slightly curved and rudely formed into merely a flattened oval, two inches and a half broad, and one and a quarter wide; the joining edge being filled by a quantity of melted solder run along both inside and outside. The section corresponds to a circular orifice of one inch and seven-eighths diameter." Leslie's *Nat. Phil.*, p. 414.

† Horat. *Epist.* i. x. 20.

‡ Ovid. *Metam.* iv. 120.

§ Statii, *Silv.* i.

and was adjusted till the water rose equally in them; the chorobates, or perambulator, which he considered as the most accurate instrument, was composed of a rod twenty feet long, having a square and plummet attached at each extremity. Vitruvius allows only half a foot in the hundred for the slope of an aqueduct. After water had reached the walls of the city, it was admitted into a reservoir or *castellum*, divided into three distinct and equal compartments, one to feed the pools and fountains, another to supply the public baths, and a third for the accommodation of palaces and private houses. The distribution of the water was commonly effected by leaden pipes. The smallest of these was called a *denaria*, being ten feet in length, the sixteenth part of this in breadth, and weighing 120 Roman pounds. This gives for the thickness of the lead, exactly the quarter of an English inch. In lower situations, where the stress against the sides was greater, the pipes appear to have been made proportionably stronger.

"The quantity of water delivered from the cisterns, was regulated by the dimensions of the spouts, termed *calices*. These formed a series of twenty-five different kinds, which served as *moduli*. Their diameters were sometimes reckoned by ounces, or the twelfth part of a Roman foot, but more commonly by quarter digits, or the sixty-fourth part of a foot. The *quinaria* seems to have been considered as the standard, and its width must have corresponded to the ·906 part of an English inch. The ajutage or length of all these spouts was the same, being twelve digits, or three-fourths of a Roman foot, and therefore equal to 8·7 English inches. Prony conjectures from very probable grounds, that such was also the altitude of a column of pressure above the mid-

dle of each orifice. This estimate gives 1979 cubic feet for the quantity of discharge of a *denaria*, in the space of twenty-four hours.

"Leaden pipes were likewise employed to carry water across vales, and over eminences. But it behoved to erect, at several incurvations, *columnaria*, or chimneys, to give vent to the air which might collect and gorge up the passage of the water. Such funnels required to be raised to near the height of the fountain head.

"Vitruvius, however, joins with Palladius and Columella, in recommending pipes of earthenware, as not only cheaper but more wholesome than those of lead. They could be formed thicker, if necessary, and might be farther strengthened and secured, they said, by an outer coating of lime worked up with oil. But such pipes not being glazed, it became necessary, before using them, to fill up the pores by a sort of *puddling*, that is to wash their inside with *favilla*, or fine wood ashes.

"No wonder, therefore, that leaden pipes were held in little estimation among the ancient Romans. They seem to have been seldom used indeed beyond the limits of the imperial city, except as auxiliaries in the smaller aqueducts. When such conduits happened to be interrupted by a narrow vale, instead of joining them by an arch thrown over the gap, the connection was sometimes formed by an inverted syphon of lead, carried on the one side down to the bottom, and brought up on the other."*

This comprehensive and instructive summary furnishes ample materials, for estimating fairly and accurately, the scientific knowledge, and practical skill, possessed by the Romans, for the effective accomplishment of their plans. Such an assemblage of facts demonstrates that their

* Leslie's *Elements of Nat. Philosophy*, p. 416.

attainments were considerable; and the aqueducts which exist at the present period, constitute convincing memorials of their capabilities, during the most luminous epochs of their glory and grandeur. Besides, works so superb and extensive, attest the loftiness of their conceptions, as well as the extraordinary labour, perseverance, and expense bestowed upon their execution. Undeniably evident as the superiority of the moderns may be in some respects, yet it will be recollected that the advantage is the result of innumerable experiments, and the successive discoveries of many centuries.

Frequently have the baths of the ancient Romans occupied the attention of the philosopher, the traveller, and the virtuoso, and probably the singularity of these structures concurred with their magnitude to render them attractive objects of contemplation. The style of their architecture seems to have greatly varied, for the largest ever erected, although built with bricks, is represented to have been enamelled—probably with stucco. Not only sea-water but also the sulphureous waters of Albula were conveyed into those of Nero. The baths of Antoninus Caracalla were astonishingly extensive—their length being 1840 feet by a breadth of 1476. Each end had two temples, one consecrated to Apollo, the other to Æsculapius, as the tutelar genii of a place appropriated to the improvement of the mind, and the health of the body; whilst those at the opposite end were dedicated to Hercules and Bacchus, the guardian divinities of the Antonine family. The principal building had a magnificent circular vestibule with four halls on each side, adapted for cold, tepid, warm, and steam baths. That the advantage of exercise might be afforded when the weather proved unfavourable, a very large square was formed in the centre; and beyond this was a superb hall

with libraries at each end, and containing 1600 marble seats for the convenience of those who visited the baths. Both sides terminated with a court surrounded with porticos, and having a capacious basin for swimming, besides an odeum for music. The walks round the edifice were planted with trees, particularly the plane; and at its front was a gymnasium for the athletic exercises of wrestling, running, &c. in fine weather. To complete its grandeur, the whole fabric was encircled by a vast portico, in which were entrances into spacious saloons, where numerous audiences received instruction from the lectures of philosophers, and were also entertained by the recitations of poets and declaimers.

Notwithstanding the great extent of this structure, every part of its interior and exterior was adorned with splendid columns, elegant stucco work, and the finest paintings and statues. At the present time the stuccos and paintings are, in many places, still to be seen, though the colours of the latter are become faint; but the tunnels and reservoirs for water yet remain. Large as was the range of buildings, the height accorded with it proportionally; and although by the accumulated soil of ages, the ground has been raised twelve feet above its original level, the elevation is even now considerable. Much however of the space which these magnificent baths once occupied, is converted into gardens and vineyards, for which the massive walls form separations. From the number of statues that formerly ornamented these celebrated baths, it is probable that many yet remain beneath its ruins: the Farnesian Bull, and the famous Hercules were found in one of the halls; several fine pillars have also been dug up; and as the place was the receptacle of such a multiplicity of the noblest and

most beautiful productions of the tasteful and skilful artists of that era, possibly the discovery of many of them may reward the diligent researches of some curious explorer of its vestiges, at a future period. Extensive and magnificent as were the baths of Caracalla, those of Dioclesian are stated to have surpassed them, both in grandeur and sumptuousness. He is represented as having employed in their construction 40,000 Christian slaves, whom he not only ignominiously degraded, but cruelly massacred when the works were completed! The evidence for this fact, however, is rather questionable, and abominable as were the dispositions and actions of several of the Roman emperors, humanity must indulge the charitable hope, that Dioclesian's conduct was not characterized by such an atrocious deed.

Among the edifices of this kind, entitled to particular notice, were the baths of Titus, of which there still remain a part of the theatre, one of the temples, and one of the great halls, besides many subterraneous vaults, long galleries and spacious ruins. Several of the latter were very curiously painted, and the columns still retain much of their original brilliance, although so many ages have elapsed since they were executed, and their exposure to the dampness in the vaults. Many of the paintings are in the fanciful arabesque style; and as the buildings were erected at a period distinguished for a high degree of perfection in the arts, it is to be presumed that the embellishments of this structure equalled, if they did not surpass, others which had preceded it. The celebrated groupe of the Laocoon was found beneath its ruins, besides various pillars of alabaster, porphyry and granite, so that other valuable discoveries will perhaps yet be made, to evince the excellence of the sculptors of that era, and remunerate

the labours of enterprising industry in pursuit of the curious and valuable remains of the taste and skill of former ages.

Though the baths of Titus were certainly not equal to the others in magnitude, yet they exhibited the same sumptuousness, and consisted of numerous chambers decorated with the most rare and costly ornaments. The situation of those edifices likewise conduced to make them objects of peculiar interest, for they were erected on the grounds formerly occupied by the house and gardens of Macænas, the munificent patron and friend of Virgil, Horace, and Propertius, who also had residences in the vicinity. Besides it has been stated (though the authority for the fact is not unquestionable), that this was the place where once stood the tower, from which the tyrant Nero gratified his baleful curiosity, by viewing the burning of Rome, while he sang a poem on the destruction of Troy, accompanying it with the music of his harp!

Great and essential as might be the benefits and conveniences afforded to ancient Rome by the aqueducts, a diversity of other interesting circumstances concur to evince, that the accommodation of its citizens incessantly occupied attention, and prompted to the greatest exertions. While the sight was gratified with the master-pieces of art, at the same time the supply of water was augmented and facilitated to the superb mansions of its opulent residents. It is not, however, improbable that the construction of their most stupendous works for this purpose originated in the increase of voluptuous habits among the potent and wealthy Romans, rather than from the suggestions of necessity, or a benevolent desire to multiply the comforts and enjoyments of those who formed the greater portion of that renowned community.

Various as may have been the motives that stimulated

mankind, in different ages and countries, to contrive and construct works to supply water for their wants and enjoyments; however, the use of baths appears to have almost generally prevailed amongst the people of ancient times, and particularly the inhabitants of the east. In some cases religion prescribed frequent ablution as a rite, and therefore enjoined the practice as a duty; but in others it was a habit and a source of pleasurable and healthful exercise, which was cultivated and continued from one generation to another.

Probably to the change gradually introduced in the domestic habitudes and manners of the Romans, may be chiefly ascribed, the discontinuance of the use of their commodious baths, with the consequent neglect and final destruction of those splendid edifices, which were at once vast, fascinating, and commodious, comprising within their precincts every convenience conducive to health, relaxation, and amusement. A general notion of the extent and variety of institutions, forming the different parts of these grand structures, has been conveyed in former pages; but a more specific description of the several apartments peculiarly appropriated by the Romans for the practice of bathing, and likewise some notice of the buildings constructed by other nations for similar purposes may not be deemed uninteresting.

The Roman baths usually comprised six principal apartments, each of which was adapted for a different purpose. 1. The *apodyterium* where those who frequented them undressed, and laid their clothes upon tables;—persons called *capsarii*, being specially appointed to take care of them. The name *spoliatum* was sometimes given to this room, which did not form a part of every bath. 2. The *frigidarium*, or cold bath: the situation of this was commonly towards the north; and it was

also used for the purpose of undressing, when the baths had not an *apodyterium*. 3. The *tepidarium* adapted for containing temperate air, its chief object being the prevention of any injury to the bathers, from their passing too suddenly out of a very warm room, into another that was cold. The agreeable temperature of the air, rather than the use of the waters of the baths, formed the principal inducement with many of those who visited the *frigidarium* and *tepidarium*. 4. The *laconicum*, which derived its name from the stove or oven constructed in it, for the purpose of rendering it very hot. An ancient writer states, that when persons had acquired a perspiration in the *laconium*, they anointed themselves with oil previous to going into the cold bath; and that this room was originally used by invalids and valetudinarians only. 5. The *balneum* or warm bath; this was that kind of bathing which attracted the greatest number of persons; and the capaciousness of the bath was generally proportionate, so that many could be accommodated at the same time. This apartment had likewise the name, *thermelousia*, and its height usually exceeded the breadth by one-third; but this was exclusive of the *schola*, or gallery formed round its interior, and terminating near to the basin by a low wall, that served for a leaning place to such persons as might be waiting for their turns to bathe. The usual situation of the basin was directly below the single window, by which alone the light entered, thus preventing the shadows of persons walking from falling upon the water. 6. The *elcothesium*, or *unctuarium*, was the room appropriated for the preservation, and application of the oils and perfumes employed both before and after bathing; and its situation and construction adapted it for receiving a considerable degree of heat to aid the operations of the unguents. Though this

kind of arrangement generally characterized the Roman baths, nevertheless, their appendages and conveniences varied in number and extent, according to the taste and views of their respective possessors, or as they might be intended for public use or private enjoyment. It has been estimated that the baths of Antoninus Caracalla would accommodate 1800 persons to bathe at one time. The rotunda, or grand hall, belonging to this capacious building, was 111 feet in diameter; but these baths were alike conspicuous for grandeur of design and diversity of objects comprised in them, exhibiting a remarkable contrast to the modest structures which Pliny has described in one of his letters, as forming a part of his villa at Laurentinum.*

As the warm baths were so capacious, the modes employed to heat the large quantity of water required for them naturally excites surprise. This appears to have been effected by furnaces to which the name of *hypocaust* was applied. The baths of Caracalla had a water tower to receive their supply from one of the aqueducts which passed near to the Appian way; and the reservoir for its purposes was so constructed, as to have twenty-eight vaulted chambers immediately over the *hypocaust*: these chambers consisted of two ranges, each having fourteen, and communicating with each other; but twenty-eight more, with similar dimensions and connections, were erected upon them, though only one of the upper had a communication with the lower chambers. Upon this double tier of vaults the spacious but shallow reservoir was formed, extending the whole length of the water tower; and the water being exposed to the sun, imbibed some portion of heat, before it passed into the

* Plinii, *Epist.* 17. lib. ii.

chambers adapted for augmenting its temperature to a high degree. Besides, in order to prevent its being agitated, it flowed from the aqueduct into an intermediate cistern before it passed to the reservoir; and the same cistern had also a contrivance by which the water escaped through an aperture formed on one of its sides, whenever it became necessary to remove it. The interior dimensions of the several chambers will show the abundant supply that they were calculated to afford, for their average length was forty-nine feet, by a height of thirty, and a width of twenty-seven; so that the lower chambers alone would contain more than 1,000,000 cubic feet of water.*

Another mode of heating water for the baths is described by Seneca; and, according to his statement, this was effected by a species of vases that were high and narrow, with fanciful shapes, some in the form of dragons. In these were placed spiral copper pipes, through which the water passed to acquire the necessary degree of heat; and as the hot water flowed out of them, the cold water entered, so that the whole obtained the same temperature by passing through the pipes. Seneca mentions, as an advantage attending this process, that the water having no communication with the fire, whilst it flows through pipes, the vapours are not contaminated with smoke. Having described the devices of the Romans, we cannot avoid indulging in a few reflections, before proceeding to occupy attention with some of the practices of other nations.

The great ability and success which characterized the splendid achievements of the Roman people, in poetry, eloquence, architecture, and military enterprizes, will

* It is stated that Rome, at one time, contained no less than 870 baths.

probably eternize their fame. Essentially and obviously useful, however, as the aqueducts proved to the capital of the Roman empire, especially in the zenith of its glory, their extent and magnitude concur to demonstrate that the cost of erecting them must have been enormous. On these and other great undertakings, the wealth and labour of nations were profusely lavished by a few powerful individuals; and, as elaborate productions of human ingenuity, they irresistibly excite the astonishment of beholders. If, however, the fervour of imagination prompt the poet to eulogize them, as

> "Imperial works and worthy kings,"

other feelings will affect the philanthropist from his cherishing a benevolent regard for the happiness and welfare of his species. To him they become a source of pensive sentiment and moralizing reflection; for, whilst impressed by their grandeur, and acknowledging their utility, his sympathies may lead him to ponder over the circumstances concerned in their accomplishment. And amongst the most prominent, will not humanity be constrained to reckon the devastation of fertile countries, the dissolution and plunder of peaceful communities, the slavery of virtuous and noble-minded men, probably with the sole view of ministering to the casual and temporary caprice of luxurious pride? Indeed, how often has the lust of wealth, power, and glory, debased the minds and actuated the conquerors of nations? Is it an unreasonable inference that their construction was probably effected, by the unceasing toil and misery of millions, doomed to labour and suffer, without ever hearing the kind and soothing accents of compassion, to alleviate their sorrows and calamity? Peradventure, the reflection may also arise, that among those employed might be many of the

countrymen of Caractacus and Boadicea, who were alike distinguished for their love of freedom, and attachment to their native land, though deemed barbarians, in the scornful estimation of ambitious Romans. Such melancholy sentiments will sometimes forcibly commix with others in the mind of a modern Briton, whose generous concern for his fellow-men may perhaps occasion the sigh of pity, to accompany the throb of indignation, whilst viewing these superb reliques of antiquity.

Happily, however, in modern times, various circumstances have concurred to ameliorate the political and civil condition of a large portion of the human species; and the same potent causes continue to operate, so as to render it improbable that mankind will ever again encounter such vicissitudes, privations, and calamities, as befel their unfortunate progenitors, from the ruthless ambition of military leaders. Civilization and refinement being extensively diffused amongst the principal nations of the world, will infallibly exercise their beneficent influence to prevent a whole people from being permanently enslaved, and the noblest patriots chained to the triumphal car of a haughty victor, for the purpose of augmenting the splendour of his processions, or adding to the number of his trophies. By the spread of knowledge, more correct and elevated notions concerning the social relations have been successfully inculcated; hence, rational man has attained a higher rank than that of being considered as a kind of property, that may at any time be violently seized by the rude hands of lawless power, and employed for any purpose that changeful caprice or unfeeling pride shall happen to suggest.*

Besides the obvious benefits resulting to the commu-

* This was written before the late melancholy transactions in Poland.

nity from the more general propensity to promote intellectual improvement, mechanical ingenuity being powerfully aided by the discoveries of chemical science, has greatly diversified the means of commercial enterprize. Numerous individuals have thus been stimulated to an extraordinary degree of activity in their respective pursuits, and by signal diligence and industry made those pecuniary acquisitions which naturally tend to increase their influence in society, as well as to generate feelings of personal dignity and independence. To these causes may be ascribed many of the great works which have been devised and executed for public purposes; for they have not commonly originated in the imperious commands of a despotic potentate, and merely to gratify his exclusive vanity or taste; but, on the contrary, they have been generally undertaken as objects of private profitable speculation, though in some instances constructed at the national expense, from the evident utility of their accomplishment. How different are such motives from those formerly actuating Roman consuls and emperors, who, regardless of the miseries of others, luxuriated in enjoyments, and embellished that celebrated city, by plundering their neighbours and distant nations!

Considerations of economy may have precluded much display of external magnificence, in the execution of some public works; nevertheless, the rapid and striking progress of both the fine and useful arts, during the last and present century, affords abundant evidence of the encouragement bestowed upon them, as well as the prevalence of refined taste, enlightened views, and liberal sentiments. Notwithstanding, some persons have strenuously maintained that commercial occupations inevitably tend to contract the mind by generating a sordid disposition, yet, the noble and superb structures now adorning

London, Liverpool, Edinburgh, and many other places, may be adduced as instances to vie with some of those which formerly embellished Imperial Rome. The docks, canals, rail-roads, bridges, arsenals, and other works, constructed during a comparatively recent period, and conspicuous alike for utility and magnitude, surpass many of the boldest productions of that much celebrated era. Indeed, if it were possible for an old Roman to rise from his grave, to contemplate the extent of our navies and commerce; the amazing power and diversified applications of the steam-engine; the wide diffusion and brilliance of our gas-lights; the number of our large founderies and manufactories, with the infinite variety of contrivances, which not only distinguish every branch of art, but are likewise made subservient to the various wants, enjoyments, and conveniences of social life, he might be disposed to conclude, that he actually lived in the infancy of the world, proudly as he once vaunted of his superiority over the mass of mankind. Posterity, however, may eventually form a similar estimate of the acquirements and enjoyments of the present period, when they shall be advancing in the career of improvement, with all the great advantages resulting from the accumulated knowledge, and innumerable inventions of preceding ages!

CHAPTER XII.

Baths of Egypt; much frequented by Women: Mode of Heating them. Construction and Elegance of those in Turkey. Alhambra in Spain: its admirable situation; singularly superb and capacious Baths. Simple Plan of constructing Baths in Russia: Method of preparing them for Use. Practice of Bathing in general; Notions of its being Salubrious, &c. Hot Baths of Hungary. Conveniences for Bathing in Great Britain very limited. Birmingham Baths: their Dimensions and Advantages.

THE baths of Egypt have been described by M. Savary in his usual admirable style; and he observes, that "hot baths were known in the remotest ages, and celebrated by Homer, who paints the manners of the times. From whatever causes all their allurements and salubrity proceeded, necessity has rendered them common in a country, where perspiration is abundant, and pleasure has preserved the practice. Mahomet, who knew their utility, has made them the subject of a religious precept. They have been superficially described by most travellers, but as my habit of frequenting them has afforded me opportunities of examining them attentively, I shall endeavour to be at once particular and satisfactory.

"The first apartment at entering the bath is a great chamber, in the form of a rotunda, with an open roof to let the pure air circulate freely. A spacious alcove carpeted, is carried round and divided into compartments, in which the bathers leave their cloths. In the centre is a fountain that plays into a reservoir and has a pleasing effect.

"When undressed, a napkin is tied round the middle, sandals are put on, and a narrow passage is entered, where the heat first begins to be felt: the door shuts, and twenty paces farther a second opens, which is the entrance to a passage at right angles with the first. Here the heat augments, and those who fear to expose themselves too suddenly to its effects, stop some time in a marble hall before they enter. The bath itself is a spacious vaulted chamber, paved and lined with marble; beside it are four small rooms; a vapour continually rises from a fountain and cistern of hot water; with which burnt perfumes mingle.

"The bathers are not, as in France, imprisoned in a kind of tub, where the body cannot be in a state of ease; but reclining on a spread sheet, and the head supported on a small pillow, they freely take whatever posture they please, whilst clouds of odoriferous vapours envelope and penetrate every pore.

"Having reposed there for some time, a gentle moistness diffuses itself over the whole body; a servant comes, gently presses and turns the bather, and when the limbs are flexible, makes the joints crack without trouble; then seems to knead the body without giving the slightest sensation of pain.

"This done, he puts on a stuff glove, and continues rubbing long, and freeing the skin of the patient, while it is wet, from every kind of scaly obstruction, and all imperceptible particles that cloy the pores, till it becomes as smooth as satin: he then conducts the bather into a cabinet, pours a lather of perfumed soap on his head, and then retires.

"The ancients honoured their guests still more, and treated them in a more voluptuous manner. While Te-

lemachus was at the court of Nestor,* 'the beauteous Polycaste, youngest of the daughters of the King of Pylos, led the son of Ulysses to the bath, washed him with her own hands, and having rubbed his body with precious ointments, clothed him in rich garments, and a shining mantle.'—Nor were Pisistratus and Telemachus worse treated in the palace of Menelaus,† the beauties of which having admired, they were conducted to marble basins, in which the bath was prepared, where beauteous slaves washed them with odorous oils, and clothed them with fine garments and magnificent furred robes.

"'The room in which the bather retires, has two water-cocks, one for cold, the other for hot water, and he washes himself. The attendant presently returns, with depilatory pomatum, which instantly eradicates hair wherever it is applied; and it is in general use both with men and women in Egypt. Being well washed and purified, the bather is wrapped up in hot linen, and follows his guides through various windings, that lead to the outer apartment, while this insensible transition, from heat to cold, prevents all inconvenience; and having arrived at an alcove, a bed is ready prepared, on which the person no sooner lies down than a boy comes, and begins to press with his delicate hands, all parts of the body, in order to dry them perfectly. The linen is once more changed, and the boy gently rubs the callous skin of the feet with pumice-stone, and then brings a pipe and mocha coffee.

"Coming from a bath filled with hot vapour, in which excessive perspiration bedewed every limb, into a spacious apartment and the open air, the lungs expand and expire

* Odyssey, Book III. † Ibid, Book IV.

with pleasure: well-kneaded, and as it were, regenerated, the blood circulates freely, the body feels a voluptuous ease, a flexibility till then unknown, a lightness as if relieved from some enormous weight, and the man almost fancies himself newly born, and beginning first to live. A glowing consciousness of existence spreads itself to the very extremities; and while thus yielding to the most delightful sensations, ideas of the most pleasing kind pervade and fill the soul. The imagination wanders through worlds which itself embellishes, every where drawing pictures of happiness and delight. If life be only a succession of ideas, the vigour and rapidity with which the memory then retraces all the knowledge of the man, would lead us to believe that the two hours delicious calm, which succeed bathing, are an age.

"The women are passionately fond of these baths, where they go at least once a week, taking with them slaves accustomed to the office. More sensual than men, after the usual process, they wash the body, and particularly the head, with rose-water. There their attendants braid their long black hair, with which, instead of powder and pomatum, they mingle precious essences. There they blacken the rim of the eye-lid, arch the brows with *cohel*, (tin burnt with gall-nuts), and stain the nails of their hands and feet of a golden yellow. Their linen and robes having been passed through the sweet vapour of aloes wood, and their dressing ended, they remain in the outward apartments, and pass the day in feasting, while singing girls come and dance, and sing soothing airs, or recount amorous adventures.

"The days of bathing are festive days with Egyptian women; they deck themselves magnificently, and under the long veil and mantle which hide them from the public eye, wear the richest stuffs. They undress themselves

in the presence of each other, and their vanity extends even to their drawers, which, in winter, are made of stuffs inwove with silk and gold, and in summer of worked muslin. Ruffles and lace are unknown to them, but their shifts are made of cotton and silk, as light and transparent as gauze. Rich sashes of cassimere bind up their floating robes; and two crescents of fine pearls sparkle amidst the black hair that shades their temples; while diamonds enrich the Indian handkerchief with which they bind their brows. Such are the Georgians and Circassians whom the Turks purchase for their wives. They are neat to excess, and walk in an atmosphere of perfumes; and though their luxury be hidden from the public, it surpasses that of European women in their own houses."*

This minute and fascinating picture, energetically conveys much interesting information, concerning the baths and practices of the Egyptians; but M. Savary has omitted to state what means are employed either to heat, or supply the water for their purposes. Probably, however, the method practised, in both cases, is similar to that employed by the Turks, whose baths, with their mode of preparing and using them, it shall be our endeavour to describe.

Baths form an essential part of the domestic arrangements of the Turks, both in their towns and villages; and persons who may not have any at their own houses, are accommodated at a public one erected for the purpose. The private baths have generally small dimensions, and are connected with their residences by a room, in which the bathers take off their clothes. They consist of two apartments built with bricks, and communicating with

* *Travels in Egypt.*

each other. The interior walls are usually faced with marble or plaster; and the light is admitted through chequer work on the top of small cupolas. They have smooth wooden seats, and the floors are laid with marble, having grooves cut in them for carrying off any water that may fall upon them. Double folding doors, covered with woollen cloth, and edged with felts, are fixed at each end of the short passages between the two rooms. The mode of heating them is by a subterranean vault, having its entrance on the outside of the building, and the marble floor of the bath being its ceiling. Immediately under the latter is placed a large cauldron, containing water, heated by a wood fire, which is commonly made twenty-four hours before the baths are used. Pipes proceeding from the cauldron, and fixed in the walls, ascend the sides of the bath to the cupola, where the steam escapes, the water being kept constantly boiling. Similar pipes for supplying cold water from a cistern are also fixed in the walls, both being situate near to each other, and likewise fitted with proper cocks, so that either hot or cold water may be readily obtained. From the peculiar construction of these baths, and their being heated so long previous to being used, the temperature of the rooms becomes very high, so that persons after undressing cannot with safety enter even the first room, till they have adapted their lungs for the purpose, by stopping a short time between the doors of the passage leading to it. But as the fire is directly under the marble floor of the second room, sandals of wood are commonly worn to prevent the feet from being affected by the great heat of the floor; and here the temperature so far exceeds the other, that a similar precaution is usually employed before entering it. The effect produced by being thus enveloped in very hot air is that of profuse

perspiration issuing from all the pores of the body; and, notwithstanding the extremely high temperature of these baths, the Turkish women not only stay in them for several hours together, but visit them frequently.

Though the private baths of the Turks are commonly small, the interior of some of them have a great degree of elegance. Lady Wortley Montague gives the subsequent description of one, which she had an opportunity of inspecting. "Two apartments are built exactly in the same manner, and answering to one another. The baths, fountains, and pavements, are all of white marble; the roofs are gilt, and the walls covered with Japan china. Adjoining to them are two rooms, the uppermost of which is divided into a sofa, and in the four corners are falls of water from the very roofs, from shell to shell of white marble, to the lower end of the room, where it falls into a large basin surrounded with pipes, that throw up the water as high as the roof. The walls are in the nature of lattices; and on the outside of them, there are vines and woodbines planted, that form a sort of green tapestry, and give an agreeable obscurity to the chambers.

Thus it will be obvious, that the wealthy Turk renders this simple luxury a source of varied gratification to the senses, while, at the same time, it conduces to health and cleanliness. Among the oriental nations, the regular and constant use of baths still continues, although in those parts of Europe, where the same practice formerly prevailed, it has been gradually diminishing during several centuries, and in some instances it is almost wholly discontinued.

Extensive and commodious as were the baths of Rome and Constantinople, and astonishing as may have been their magnificence, Spain contains a structure of the

same kind, which is equally singular and superb. The large and splendid baths at Alhambra formed a part of the palace of the Moorish kings of Grenada, and they may be considered as a remarkable instance of the taste, prevalent at the period for such healthful enjoyments, and undebasing luxuries. Besides the style of the buildings has not only a peculiar character, but probably they afford some of the finest existing specimens of Arabian architecture. The edifice consists of numerous apartments, several of them having lofty arched roofs, supported by elegant marble columns; and some of the baths are constructed sixty feet below the surface of the ground. One of these has a length of 102 feet, by a width of fifty; six others being inclosed by a wall six feet thick; and nearly the whole of the lower part of the long range of buildings is occupied by cisterns, which are constantly supplied with running water obtained from a hill, at about a league distant.

The court of the Lions forms a very remarkable part of this splendid edifice. It is one hundred feet long, fifty feet wide, with a colonade on each side seven feet wide, and at each end ten feet. The pavement of the latter is white marble, but that of the square consists of coloured tiles; and two porticos, about fifteen feet square, project into the courts. To the height of about five feet, the walls have a chequered covering of blue and yellow tiles, and the ceiling of the portico is finished with exquisite skill. The stucco is laid on the wall with extraordinary delicacy, and that on the ceiling is frosted with astonishing ingenuity. The columns supporting the roof and gallery are white marble, being not only very slender, but fantastically decorated; their height is about nine feet, including the base and capital, with

a diameter of eight and a half inches. Their arrangement is very irregular, some being placed singly, others in groups consisting of three, but most commonly two together; and the arches rising from them are constructed larger than a semi-circle resembling the form of a horse-shoe. Besides in the placing of the columns not the slightest regard has been paid to regularity, or erecting them opposite to each other. Though the designs for the capitals of the columns are various, yet each is repeated several times in the circuit of the court; and they are exquisitely polished; each arch has about it a large square of arabesque, with a rim containing a quotation, generally from the Koran. Besides, another square of beautiful filigree work is placed over the pillars; and also a little higher a cornice of wood richly carved, like the stucco which covers the walls. It is remarkable, that amongst the great diversity of foliages and grotesque and fanciful ornaments, not the slightest representation of animal life is perceivable. In the centre of the court stands a large fountain, called the *Fountain of Lions*, consisting of twelve muzzled lions, which support on their hinder parts, an enormous basin, above which a smaller one is fixed upon a pillar, containing a large *jet d'eau.* This threw up a large quantity of water, when the conduits were in a proper condition, and descending into a basin, it thence flowed from the mouths of the lions into a large reservoir beneath; which, by various channels, communicated with and supplied several other *jets d'eau*, constructed for amusing display in the different apartments.

The *Fountain of Lions* is formed of white marble, and it is ornamented with a variety of festoons. Arabian verses are also inscribed upon it, which savour of oriental

extravagance, both as regards sentiment and expression, as will be evident from the following translation :—

"Seest thou how the water flows copiously like the Nile?
"This resembles a sea washing over its shores, threatening shipwreck to the mariner.
"This water runs abundantly to give drink to the lions.
"Terrible as the lion is our king in the day of battle.
"The Nile gives glory to the king, and the lofty mountains proclaim it.
"This garden is fertile in delights: God takes care that no noxious animal shall approach it.
"The fair princess who walks in this garden, covered with pearls, augments its beauty so much, that thou mayst doubt whether it be a fountain that flows, or the tears of her admirers."

On the south side of the colonnade is a large room built in a circular form, and having a fountain in the middle, for the purpose of producing a refreshing coolness in the apartment during the sultry heat of summer. This was appropriated for the use of men only; and here they were accustomed to regale themselves with coffee and sherbet. The construction of this superb hall seemed to be altogether adapted to excite voluptuous emotions, for exclusive of its pleasing form, the skilful manner in which the walls were stuccoed, the exquisite designs for adorning them,—being also painted and finished by the utmost efforts of art,—its elegant cupola, and the admirable distribution of the light from above,—produced such pleasurable effects, as no words, however forcible, or significant, can adequately depict.

Besides the rooms already enumerated there were various others, some of which had fountains with *jets d'eau*, and others marble cisterns for the purpose of washing children. Different apartments were likewise appropriated for grown persons; and these contained cisterns formed with large slabs of white marble, the walls being

decorated with variously-coloured earthen tiles, and the light admitted into them by apertures formed in the coved ceilings. The thickness of the walls forming some of these rooms was fifteen feet, and others nine feet. The distance from the floor to the top of the cornice measured thirty-six feet; and from that to the top of the cupola eighteen feet. The lower range of windows had a height of thirteen feet; and the centre of one arch nearly forty-eight feet. To complete the whole, vaults contained boilers and stoves that supplied some of the baths with hot water, or vapour, as might be desired; and the reason for constructing several of them, at so great a depth below the surface of the ground, was evidently to keep the water in them constantly cool,—a luxury much sought in hot climates. The descent to the subterraneous baths was effected by various flights of steps gently turning, and admirably contrived for the purpose.

The situation of the palace, of which these baths form a very conspicuous portion, is one of the most delightful in the country; and every thing connected with the place appears to have been studiously contrived, and skilfully adapted, to render it an appropriate retirement for voluptuous enjoyment, in the summer season. The doors and windows of the apartments were so arranged as to admit the free circulation of air; besides a plentiful supply of water was always in readiness to produce a refreshing coolness even in the hottest months. Its gardens had shady walks abounding with aromatic trees; and the beautiful hills and fertile plains, interspersed in the country around it, afforded noble and picturesque views. The circumstances and scenery altogether were indeed so exquisitely and transcendantly enchanting, as would seem almost to surpass the power of imagination to conceive, or language to convey One traveller who viewed

the ruins of this superb palace and its baths, represents his emotions on the first view, as if he were "on a sudden transported into fairy land," and that this assemblage of edifices appeared to realize the fanciful and fascinating scenes, faintly delineated in the Tales of the Genii, and the Arabian Nights.*

The baths of the Russians are constructed in a style of great simplicity comporting with the original purpose of such contrivances. They are generally situate on the bank of a running stream, and consist of a mean wooden house, or where wood may be scarce, a cavern excavated in the earth by the side of a river. The bathing room has three or four benches placed one above another, and contains a large vaulted oven, which is heated to such a degree as renders the paving stones placed upon it red hot; but for the purpose of boiling the water a large iron vessel is fixed in brickwork contiguous to the oven. A few apertures are formed in different parts of the roof in order that the vapour may escape; and the cold water flows in by small channels. To some of the baths a kind of anti-chamber is constructed for the purpose of undressing and dressing; but this convenience very seldom belongs to them, and they usually take off their clothes in a court which has a boarded fence, with a number of benches. These accommodations commonly belong to the government, and are under the superintendence of the police. The heat of these bathing rooms averages from 100 to 120 degrees of Fahrenheit's thermometer, and this is often much augmented by throwing water

* *Swinburne's Travels in Spain;* but the most minute and accurate description of the palace and baths at Alhambra, has been given by Mr. Murphy, an architect, who in 1815 published a very splendid work in large folio, containing numerous elegant engravings, which represent the different structures and apartments, with the elevations, plans, and dimensions of each.

every few minutes upon the red hot stones of the oven. Though the baths in the palaces of the nobles may be more elegant, and have some other conveniences, yet their construction is equally simple.

Among the lower order of Russians hot baths are not only very common, but in general are deemed preferable to medicines, which they seldom take, conceiving that a sweating bath is a much more efficacious remedy for disease. Indeed their prepossessions in favour of baths, show that they do not consider such conveniences as luxuries merely, but as indispensable necessaries of life: hence, they are frequented by people of both sexes, and all ages, whatever may be their condition, and whether in a state of sickness or health, fatigued by hard labour, or a long journey.*

In those countries which abound in certain kinds of minerals, and where hot springs are common, the inhabitants render them subservient to their pleasures, and seem to luxuriate in the enjoyment of warm baths. At Buda, and other places in Hungary, such baths are represented to be actually crowded with men, women, and children of various conditions, indiscriminately bathing together, and therefore presenting a spectacle, at once curious, singular, and amusing. Townson has given a humorous description of the scene, but he enumerates some circumstances, which have a tendency to excite unpleasant emotions in a delicate mind.†

Universal as may be the use of baths in the countries inhabited by the followers of Mahomet, and extensive as is the practice in some others, to how limited an extent

* *View of the Russian Empire*, by the Rev. W. Tooke, who once told the writer, that the disease commonly called in England —"*a cold*"—was unknown in Russia!

† *Travels in Hungary.*

has this healthful and cleanly custom prevailed in Great Britain, so distinguished for its refinements and improvements in the useful arts? Indeed, how few are the conveniences properly adapted for such enjoyments! Even its great metropolis scarcely furnishes a bath that would afford a gratification to an expert swimmer! The floating baths on the Thames, like those on the Seine, are too circumscribed in their dimensions, for such a purpose; and are trivial in comparison with the capacious basins that formed a part of the magnificent baths of ancient Rome.

It is remarkable that, almost infinitely diversified as have been the projects, characterizing different eras of speculation, excepting the propositions of the New River Company and Mr. Martin, not one scheme has appeared, having as its professed object, the constructing of noble baths for public and private accommodation, in the vicinity of London, or other large towns. As an exception to this assertion, perhaps the baths at Birmingham may be mentioned; and those were constructed at the expense of an opulent private individual with a view to profit, by furnishing a great convenience to the public. They comprise hot and cold baths, with a room for sweating; and that for swimming has a length of 108 feet by a breadth of 54. The latter is placed in the centre of a garden, with twenty-four undressing-rooms attached; and the whole is surrounded by a wall ten feet high. The water flows constantly into it from a very fertile spring, called Lady Well, so that it is always clear and cool, without ever being defectively supplied. Those who frequent these baths have the choice of paying either an annual or quarterly subscription, or a very moderate sum, each time, for using them.

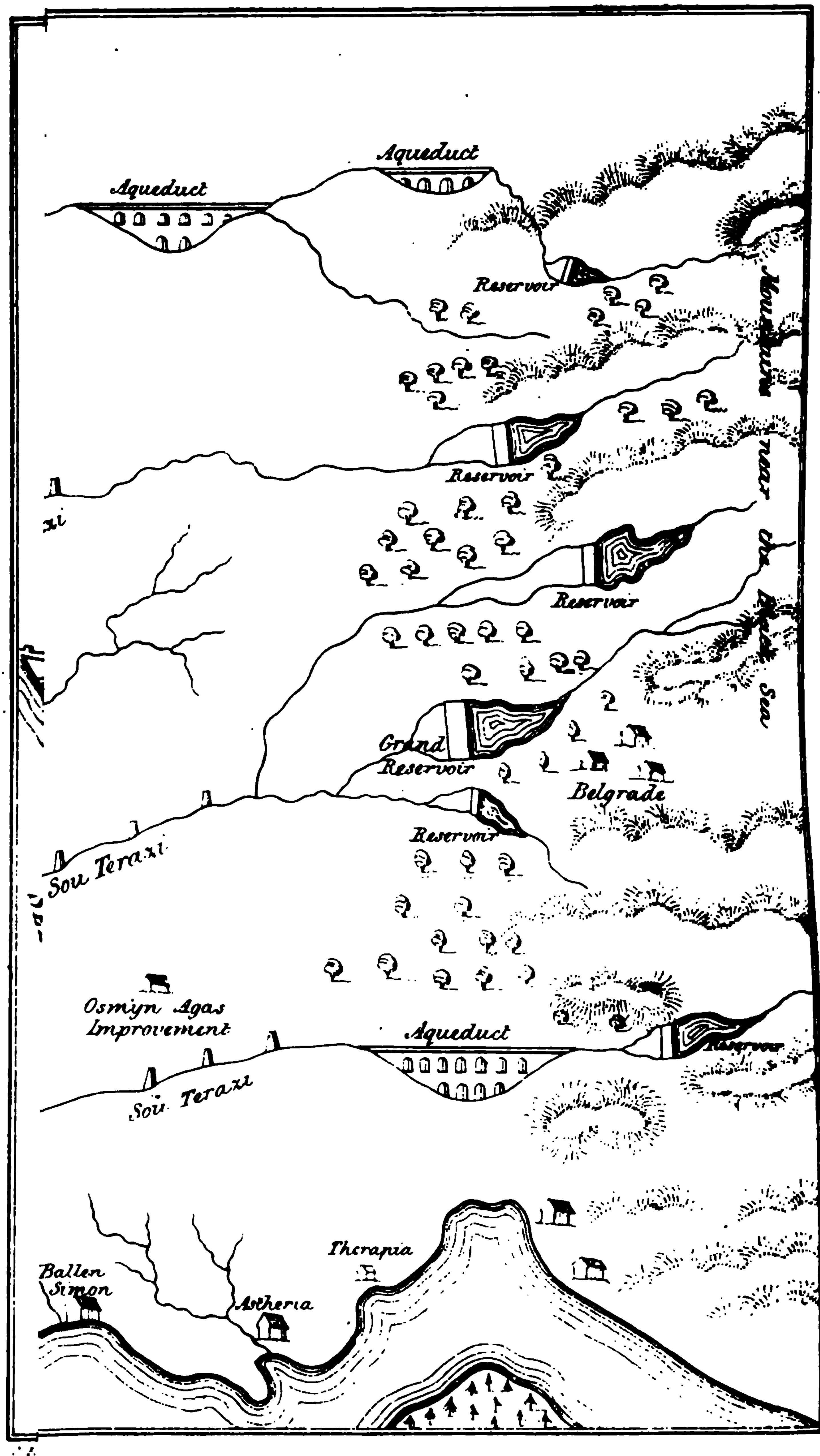
In the latter part of the last century very convenient

public baths were constructed at Florence, with every convenience for general accommodation; and at Paris baths are numerous, and adapted to all classes, and each sex;—there is also a school for swimming.

CHAPTER XIII.

Constantinople,—its fine Situation; but naturally defective in Springs, &c. Contrivances for Supplying it with Water. Hydraulia: Rigorous Edicts to preserve the Conduits from injury. Source of the Water; Mode of Constructing Reservoirs. Sou-terazi. Fountains. Aqueducts; Peculiarities in their Construction. Subterraneous Cisterns. Philoxenon. Bagnios;—that of Zeuxippus. Mahomet II.: his Fountain and Bath. Caravanseras. Bathing generally a favourite enjoyment of the Turks. Public Baths numerous in Constantinople. Water-works confided to a particular class of men. Practice of persons who sell Water. Alarm about a deficiency; Indications of the approach of Rain the same as in Syria. Present Sultan disposed to encourage improvements.

The means devised for conveying abundance of water to ancient Rome excite admiration; but the Romans also directed their efforts to afford similar advantages to other cities and countries subjected to their domination. Amongst the remarkable structures for this purpose may be enumerated the aqueducts and cisterns constructed to benefit Constantinople, after it became the capital of the lower empire. These extensive and stupendous works demonstrate the magnitude of their conceptions, and the earnestness of their exertions to accomplish an object of the highest importance to the health, necessities and conveniences of the inhabitants.


Aqueduct
Aqueduct
Reservoir
Mountains near the Black Sea
Reservoir
Reservoir
Grand Reservoir
Belgrade
Reservoir
Sou Teraxi
Osmyn Agas Improvement
Aqueduct
Reservoir
Sou Teraxi
Therapia
Ballen Simon
Artheria

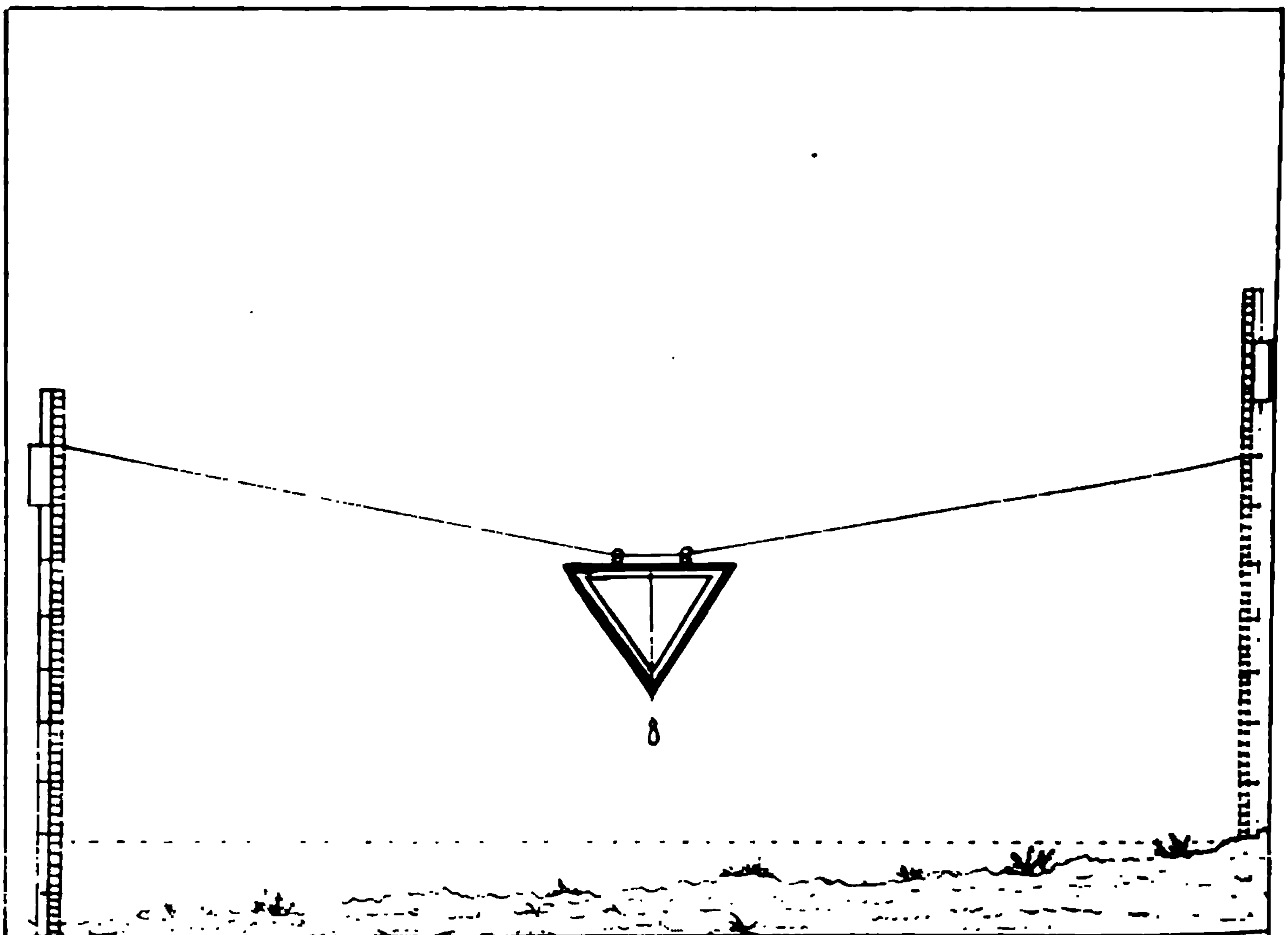
Besides the peculiar contrivances introduced for effecting the object not only attest the persevering attention bestowed upon the subject, but likewise display their ingenuity in diversifying plans, and simplifying inventions, as well as their improved skill in adapting them to particular situations and circumstances.

The site of Constantinople surpasses, in many respects, that of any other city in the world. Being erected on a triangular peninsula composed of seven hills, two of its sides are washed by the sea; and besides having a great elevation, it is also surrounded with prospects of the most beautiful, enchanting, and picturesque scenery. Though possessing these and various other singular advantages, yet it is naturally deficient of one benefit most essential to the domestic wants and comforts of mankind. The only streams in its vicinity flowing towards the city, are two rivulets, anciently called *Barbyses* and *Cydares*, both of which have very trivial currents at any time, but in the summer season, it is not unusual for them to be nearly or altogether dry. To this may be added another inconvenience;—the springs are very few, and these produce only a small quantity of water. Hence, different Roman emperors endeavoured to remedy the defect, and provide for the positive wants of a large population by the adventitious resources of art; but the works constructed by their direction were subsequently augmented and improved by several of the Turkish Sultans.

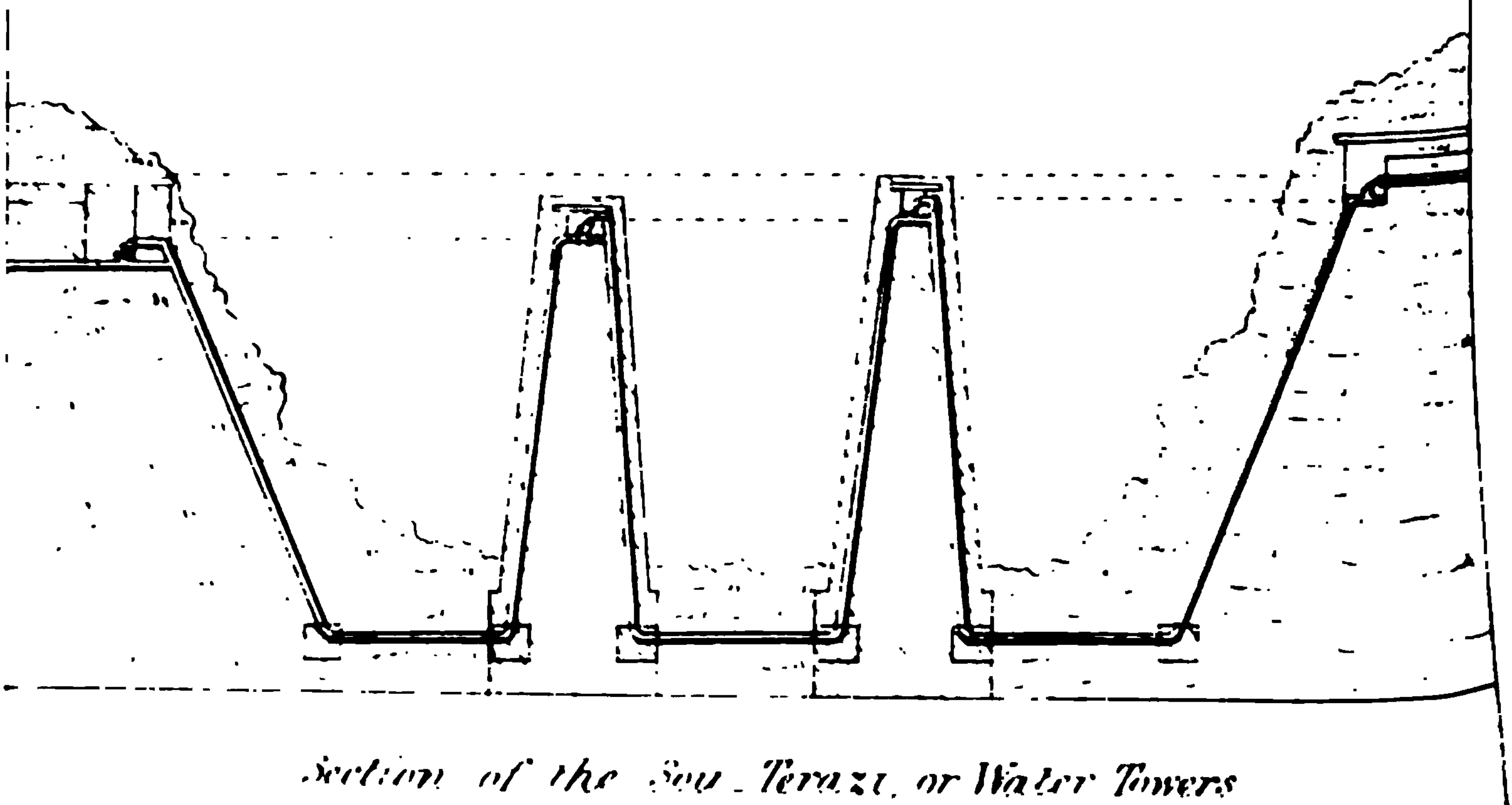
One of the plans first adopted was the construction of cisterns below the houses, to preserve the rain whenever it fell; but the quantity of water obtained by this means proved insufficient for the common wants of the people. Happily, however, another prolific source presented itself near to the shores of the Black Sea, which

facilitated the adoption of a noble and an effective project, for procuring an abundant supply. As the plentiful dews and frequent showers of this mountainous district occasion many streams to flow down the intervening valleys, the idea was suggested of constructing mounds at certain elevations, to intercept the different descending currents, so as to collect and render them subservient to the uses of the city. Large triangular reservoirs were thus formed of great depth and capacity. The breadth and height of the mounds are not only considerable, but being also faced with white marble finely sculptured in the oriental style, they exhibit a bold and magnificent appearance. The construction of these reservoirs, and the conduits from them, is generally attributed to the Greek emperors, and their importance may be estimated by the solicitude evinced to preserve them from injury, or depredation. With this view various edicts were issued, some of which relate to the planting of trees upon the embankments, whilst others prohibit the abstraction of water from the reservoirs for private use; and one of these laws, promulgated in 404, imposed the fine of a pound of gold, for every ounce of water surreptitiously taken away. But as the religion of the Turks requires frequent ablutions, that render an abundance more necessary to them than to the Greeks and Jews, the former inflict the severest penalties upon every person who improperly takes it, or cuts or digs up any of the trees planted upon the borders of a reservoir.

Singularity and ingenuity characterize the method of conveying water from the reservoirs to Constantinople, and the estimated expense amounts to about one-fifth only of the sum required for erecting large aqueducts, though several of these noble structures have been formed to convey the water across the valleys. Through the



Terazi, The Instrument used for Levelling in Turkey.



Section of the Sou-Terazi, or Water Towers

greater part of its course the conduit consists of earthen pipes, but square buildings, called *Souterazi*, are erected at different points upon the declivities, between the reservoirs and the city, and the level of the top of every successive pillar in the same range varies, so that their descending direction is analogous to an inclined plane commencing at the mountains. There are several ranges of these quadrangular obelisks, which present a peculiar and rather an unpleasant prospect to persons, who may not be aware of their purpose, and therefore cannot appreciate their utility.

The principal sources of the water are about fifteen miles distant from Constantinople; and in order to ascertain the proper declivity of the ground for the line of water course, an instrument is employed resembling an inverted mason's plummet, and having the name—*Terazi*. This contrivance being suspended from the middle of a cord, stretched between two rods, accurately divided into inches and parts, and set upright, by its successive removal from station to station, the surveyor ascertains the precise slope for the gradual flow of the water.

That the current from the various sources may be sufficiently ample, every reservoir has several circular outlets of different dimensions,—the centre of the whole being placed in the same horizontal line. As the water flows in covered tunnels, having at intervals *Souterazi*, these structures were probably intended to serve a similar purpose to that of the *columnaria* employed in the Roman aqueducts, by allowing the escape of the air from the pipes, and, likewise occasioning the deposition of any feculent matter. The obelisks are so contrived that the water ascends through a lead pipe carried up the interior of one side the building nearly to its summit, where it flows into a square basin below its orifice,

and descends by a corresponding pipe placed on the opposite side. Thus the water successively ascends and descends in its course from the reservoirs, till it arrives at its destination in the city, where it occasionally rises with great force resembling a *jet d'eau.**

Contiguous to Constantinople a capacious reservoir receives the great mass of water, prior to its entering the various conduits for conveying it to that which supplies the seraglio of the Sultan, as well as the numerous fountains in different parts of the city. The latter structures are generally low quadrangular buildings, with spouts on each side, and leaden roofs curved in the Chinese manner, similar to the top of a tent, being also gaudily gilded and painted with a variety of colours, besides having upon them inscriptions in verse. These useful edifices are erected in almost every street, though, as a modern traveller remarks, "they do not indeed exhibit that splendour of architecture and ornament which Rome displays; where obedient rivers are forced into the air, or spread over artificial rocks; but they afford the pure spring and simple bowl, to invite the thirsty traveller to a delicious draught."

The aqueducts concerned in supplying Constantinople, are four in number, one of which is stated to have been constructed during the reign of Valens, and extends over the valley between the third and fourth hills. It consists of massive arches, and in a part of its length they are erected one over another, forming a double arcade. The mode of building adopted is similar to that employed for the walls of the city, which have Roman tiles and stones laid in alternate courses. It is recorded that the inhabitants of Chalcedone having opposed Valens, he resolved

* *Andreossi sur Constantinople, &c.*

to demolish its walls, and had the materials actually conveyed to Constantinople for the construction of this aqueduct.* Its dilapidations were repaired in 570, by Justin II.; but through neglect and the operation of time, its condition afterwards became very ruinous, when Suleyman the Magnificent not only restored it to its pristine state, but repaired all the ancient aqueducts for supplying the city. Perhaps this stupendous work may be deemed one of the most striking memorials and useful remains of the original grandeur of Constantinople. As this great structure is situate in the interior of the city, the course of some of the streets pass through the arches, and others along its sides. In many places vines, and various other creeping plants have fixed themselves in the crevices between the stones, where the water oozes out for yielding support to their roots, and the plentiful nutriment thus obtained, occasions them to grow with great luxuriance, so as to exhibit a very beautiful, diversified, and interesting spectacle.†

The other aqueducts are situate between the reservoirs and Constantinople, and have been erected to convey the water over some of the deep valleys. One of these structures is about 440 feet long, and 107 feet high; it consists of a double tier of arches ranged one over the other, and supported by strong buttresses which have also two arches at the upper tier, and one at the lower, this latter being for the purpose of rendering the edifice useful as a bridge for passengers, as is commonly the case in aqueducts composed of two tiers of arches. Another has twenty-one arches, of which ten are twice the magnitude of the others. This passes over the road leading to

* *Ammianus Marcellinus*, lib. xxxi., cap. i.

† *Gyllius' Antiquities of Constantinople.*

Buyukderé, and is that which was last built. There is likewise an aqueduct which conveys the water over a deep dell, and in its formation two galleries have been constructed over the arcades. The arches of the two latter have an average height and width of about sixty feet; and one of them is supported by octangular pillars, having a circumference of about 150 feet.*

The magnitude of two of the cisterns formerly employed to collect and preserve the rain-water excites astonishment; and their construction has been attributed to Constantine and Justinian. The discovery of one of these extraordinary works was made by *Petrus Gyllius*, an erudite and ingenious Frenchman, who resided at Constantinople for some time, during the early part of the sixteenth century. His account is not only interesting from its minuteness, but was the result of careful personal observation; and as its correctness and authenticity have been corroborated by subsequent travellers, his simple and impressive description will perhaps be deemed preferable to any other.

In describing the "seventh hill," he observes that "on the ridge there is a plain of some length and breadth. The hill itself is bounded by the land wall, and on its summit is a *cistern*, called *Mocisia*, wholly unroofed, and divested of its pillars. This cistern has a circumference of *nine hundred and seventy paces;* the walls still remain, and are built with square free-stone; but the ground on which it stands is now converted into a garden." Referring to a church which formerly stood on the third hill, he states, that "it is almost entirely demolished by the Mahometans, its only remains being a

* *Dallaway's Constantinople.*

few marble pillars, waiting the last efforts of their sacrilege. That this was a costly and magnificent building, appears from the *cistern* of Bonus, situate a little above it, and constructed by a nobleman of that name. Its length was *three hundred paces;* but its roof and columns are entirely ruined, and at present, its site is turned into a garden." In the same district, he likewise states, his having seen "*three cisterns*, one in the *Forum* of *Taurus*, another between the tomb of *Bajazet* and the *Bezestan*, both supported by marble pillars. The third was built on a clift of the third hill facing the north, of which there yet remain six large and lofty Corinthian pillars, made of Arabian marble and curiously wrought. Below the base of the pedestal an earthen pipe was laid for conveying water into a cistern constructed with bricks. The roof was also brick-work, and supported by twenty square brick pillars. A little above the cistern there was formerly a court belonging to a Christian church, which the Turks demolished to repair and beautify their own houses." These instances show the capaciousness of these useful receptacles for water; but those to which allusion has been made, were of a much more magnificent kind, and wholly different with regard to situation and other particulars. The relation of a few circumstances will exhibit the sagacity of Gyllius, in a very favourable light, and develope the train of reasoning by which he was led to infer the existence and site of such a stupendous excavation.

Gyllius commences his detail by observing, that "at old Rome, the *Basilicae* were the places in which the senates were accustomed to deliberate, lawyers to plead, and the transactions of trade and commerce carried on; but at Constantinople they were used as libraries and schools of learning, as appeared from some other facts as

well as the following inscription upon the public school at *Byzantium*:—

"This place was built for all th' unletter'd youth
Whose *genius* leads them to the *Roman* law;
In pleading skill'd, and fraught with eloquence,
They leave these walls, and plead their country's cause."

Modern writers tell us that the place where the library stood was of an octagonal form, with arched porticos, and a large room, where the principal master usually conversed with his assistants.—My opinion is, that the place on which the library stood was quadrangular; and it seems to be the same building that Procopius represents to be encompassed with pillars in a square manner:—Cedrinus calls the *Basilica*,—*Cisterna*—which some writers erroneously affirm, was constructed by Constantine the Great. I am confirmed in this opinion from Procopius, who states, "that near the Imperial Portico, where the lawyers used to plead, there was a spacious building of great length and breadth encompassed with pillars in a quadrangular manner, situate on a rocky ground, which was built by Justinian, to a great height, for preserving the water, which in summer, was then conveyed into it by subterraneous pipes, but in the winter from the *aqueducts* for the use of the poor." After citing some other collateral circumstances, he continues—"from these passages, it is observable that the Imperial *Portico*, and the Imperial *Cistern*, stood in the same place. The Imperial *Portico* is not to be seen, though the *Cistern* is still remaining. Through the carelesness and contempt of the inhabitants for every thing that is curious, it was never discovered excepting by me, who, though a stranger amongst them, found it after a long and diligent search. The whole ground was built upon, which made it less suspected that there

was a cistern there. The people had not any notion of its existence, although they daily drew their water out of the wells that were sunk into it. I went by chance into a house where there was a descent into it, and went aboard a little skiff. The master of the house after having lighted some torches, rowing me here and there across, between the pillars which lay very deep in water. He was very intent upon catching his fish, with which the *cistern* abounds, and speared some of them by the light of the torches. There is also a small light which descends from the mouth of the well, and reflects upon the water where the fish usually come for air. This cistern is three hundred and thirty-six feet long, one hundred and eighty-two feet broad. The roof, arches, and sides, are all brick-work, covered with terrass, and are not in the least degree impaired by time. The roof is supported by three hundred and thirty-six marble pillars. The space of intercolumniation is twelve feet; and each pillar is above forty feet nine inches high. They stand lengthwise in twelve ranges, and twenty-eight in the breadth. Their *capitals* are partly finished after the Corinthian model, and part of them not finished. Over the *abacus* of every pillar is placed a large stone, which seems to be another *abacus*, and supports four arches. There are abundance of wells which fall into the cistern. When it was filling, in the winter time, I have seen a large stream of water falling from a great pipe with a mighty noise, till the pillars have been covered with water up to the middle of the capitals."* This large subterranean reservoir was inspected a few years ago by a highly respectable modern traveller, who corroborates Gyllius's statement.†

* *Gyllius.*

† *Walsh.*

The other great cistern is very ancient, and seems to have been constructed with a benevolent view, in a favourable situation, where "stood several fine buildings, some hospitals, a place for the entertainment of strangers, which had very good spring water, and was called *Philoxenon*. Some writers affirm that it was built by a person of that name; and that Philip of Macedon cleansed most of the cisterns of the city, which Heraclius commanded to be replenished with earth. It is presumed to be the same that lies under ground, and whose roof is supported with four hundred and twenty-four marble pillars, two hundred and twelve supporting the same number above them. I measured one of them, and found it to be six feet nine inches in circumference, and all appear to be of the same size. There is another cistern on the west side of the same house, the arches of which are supported by thirty-two Corinthian pillars, standing in four ranges, each consisting of eight pillars, with shafts nine feet in compass."*

As the Philoxenon has so large a number of fine marble pillars, the Turks have denominated this structure—"*the thousand and one columns;*" and a recent observer describes it as "a vast subterranean edifice, partly filled up with earth, but still of great depth, having an arched roof supported by 672 marble columns, each column consisting of three standing on the top of each other." According to a calculation made by Andreossi, the cavity when full is capable of holding a supply for the whole city for sixty days. It is now however dry, and a number of silk-twisters having taken possession of it, they ply their trade at the bottom, in almost utter darkness"† Some other cisterns are mentioned by Gyllius,

* *Gyllius.* † *Walsh.*

as attached to churches and other edifices, however, those described above seem to have been the most important; but he mentions "the cistern of St. Benedict, now despoiled of its roof, and *three hundred pillars* which supported it, showing it to be a very antique and expensive work, though now turned into a cistern for watering the priest's gardens."

The magnificent baths constructed at Constantinople, for the convenience of the inhabitants, exhibit a regard to health and enjoyments, similar to that displayed at Rome. The bath denominated Zeuxippum seems to have been one of the principal; and Gyllius observes, that "Eusebius writes, some are of opinion the fine bathing-place at Constantinople took its name from the famous painter Zeuxes, whose pieces adorned it. Cedrinus relates, that in this *bagnio* there was a pleasing variety of prospects of surprising art, both in marble and stone-work, in statues of brass, and figures of persons of antiquity, who seemed to want nothing but a soul to animate and enliven them. Among these celebrated pieces of the most exquisite workmanship was the statue of old *Homer*, in a thoughtful posture, his beard hanging carelessly down, his hair very thin before, his face wrinkled with age, and the cares of the world; his nose well-proportioned, his eyes fixed in their sockets, as is usual with blind persons, which he was generally supposed to be. Over his close coat hung a loose garment, and under his feet, upon the pedestal of the pillar, was a bridle in brass. This place was also beautified with the brazen statues of all those renowned personages who had been famous for wisdom, poetry, oratory, or courage, throughout the world."—After enumerating nearly seventy statues of celebrated persons, he states "there were also many others; and near the *bagnio*

its shades are not equally dark, and some interesting objects diversify and cheer the dreary prospect.

When *Mahomet II.* became the master of Constantinople, about the middle of the fifteenth century, with the ruins of the Christian church, he erected a mosque, as well as an hospital, a school, and other useful buildings contiguous to it. The description of these structures, by Gyllius, is very interesting, and he represents the mosque as "embellished with a very elegant square porch as broad as the church itself, paved with the finest marble, and adorned with square porticos. The arches which sustain the roofs are supported with large pillars of marble curiously variegated. In the middle of it is a fountain with nine pipes, whose waters fall into a great basin. Round the mosque is a spacious court, part of which is inclosed with walls, and another part with a long kind of houses, some of which are inhabited by the priests and schoolmasters. In the eastern part of this court there is a garden, in the middle of which stands the sepulchre of Mahomet, built in a cylindric form of the whitest marble." After enumerating some other spacious structures "surrounded with marble pillars, and gardens adjoining to them," which altogether with the mosque occupy "a space of ground which is six furlongs in compass;" he states that "*Mahomet*, the same emperor, built in this place, where had formerly been the old *cistern* of *Arcadius*, or *Modestus*, the largest *bagnios* in all the city. These baths were of two kinds, some for men, and some for women. They adjoin each other but have different entrances, without any passage out of one into the other. I shall describe only the men's baths, because the women's are like them. The first place you enter is the room where they undress; from which you pass into

the hot, and thence into the cold bath. They all stand in one range, and are separated from each other only by walls. The room where they undress is a square structure, built of square stone up to the roof, which is arched and built with brick; the inside of it measures two hundred and fifty-eight feet in compass, and it is surrounded with an ascent of stone, above six feet broad and three feet high. The wall of this room, from the pavement to the bottom of the arched roof is thirty-seven feet high. In the middle of the floor, which is paved with marble, there is a large marble basin which is thirty-seven feet in compass, and three feet deep, which is always supplied from a fountain of spring water. There are two doors out of the undressing-room into the hot bath. This apartment is 100 feet in compass inside, and is supported by four arches which have a dome over them. It contains eight cells or bathing-rooms, one of which, being not more than half the size of the others, has the convenience of water-closets behind it, and these are cleansed by the efflux of all the water from the baths.—*Six* of these cells have a separate bathing-room adapted to each, and these are constructed in such a manner that every bathing-room has two arches which form passages to the right and left from one into another. The cells under two other arches are so contrived, that one, which is nearest the door leading from the room for undressing into the hot bath, hangs over a very large bathing-room. This latter has a marble pavement, and the Turks wash their linen in this place. A plain wall arched at the top divides the hot from the cold bath. In the middle of the former there is a fountain playing, and they communicate with each other by means of a single door. This apartment has eight arches which support its dome; and it contains eight bathing-places which project beyond the

sphere of its dome, and encircle the whole bagnio that forms a compass of about ninety feet. The whole of the pavement is laid with marble, and in the middle, it is built with an ascent in the form of an octagon, which is fifty-seven feet nine inches in circumference, and two feet and four digits high. Round the octagon there runs a channel of water, the depth of which is the same as the height of the octagon. The four inner bathing-rooms are situate in four angles, and the breadth of each is eleven feet three digits every way;—these are called *hot-houses* or sweating bagnios. The dimensions of the two bathing-rooms situate without the two arches, are the same. The other six bathing-rooms are semicircular, and stand under six arches within the circle of the dome of the hot bath. At the bottom of the pillars which support the arches, they are eleven feet in length, and five feet nine inches in breadth. Every one of these bathing-rooms has a marble cistern for the purpose of bathing; and in one of them which is above all the others, a stately marble throne is erected. There are no lights in the walls of either the hot or cold baths, though the domes are wholly illuminated by glass windows. The stoke-hole is two feet and a half in compass, and of the same height, but it is built on the outside of the baths. A constant fire is kept in it, and heats a brazen vessel, whence it emits its warm steams through pipes laid straight, and in an oblique manner, and by that means heating the bottoms of the cisterns which are used for bathing. There is a rivulet in a field situate in the suburbs, about six feet in breadth, which runs near to the stoke-hole. There are pipes laid in this brook, which convey the water through the walls of the baths to all parts of them. One of these pipes which passes through a heated earthen vessel, upon turning a cock, supplies the

cisterns with hot water; another pipe which rises higher, upon turning a cock tempers the hot water, according to the pleasure of the person who bathes."* To this minute account of these establishments may be added, that the same Sultan also united to them the Zeuxippum, besides appropriating the baths of Arcadius and Eudoxus to the use of the public, thus augmenting the accommodations for those who might be desirous of enjoying their advantages.

When Gyllius resided at Constantinople, he represents the city as containing "above a hundred public and private *bagnios*, fifty of which are very spacious, and of two lengths, much like those built by the Sultan Mahomet II. The *Caravanseras* and public inns are above a hundred, the most famous of which in the middle of their court-yard are furnished with *fountains of water*, brought from the fields adjoining the city. The Emperors particularly distinguished themselves in forming these useful structures; and thus does *Eusebius* dilate in the praise of *Constantine*—'In the middle of their *Fora*,' says he, 'you may see their fountains adorned with the emblems of a good pastor, well known to those who understand the sacred writings; namely, the history of Daniel and the lions figured in brass, and shining with plates of gold. Valens and Andronicus, at a vast expense made rivers, at a remote distance, tributary to the town, partly by directing their courses under arches, at this time appearing above ground, and partly by channels dug under it. Several other Emperors with no less cost, made themselves fish-ponds and subterraneous lakes, by after-ages called cisterns, in every ward of the city, and that principally to supply them with water in case

* *Gyllius's Antiquities of Constantinople.*

of a siege. But the enemies of Constantinople lying at such a distance they have either entirely ruined their cisterns, or converted them to another use. I shall take no notice of the stately houses of their noblemen and bashas, nor of the Grand Signor's palace, which, spreading itself all over old *Byzantium*, is constantly supplied with rivers which flow in upon it, from distant parts of the neighbouring country. I pass by the lakes and conduits, seated in every part of the city, which serve not only for water to drink, but likewise carry off the filth of it into the sea, and wash away those impurities of the town which clog and encumber the air, and for which great cities are generally looked upon as unwholesome." From the above detail, it will be obvious that with respect to the plentiful supply of water, this celebrated city then continued to enjoy many advantages, notwithstanding the desolation resulting from the negligence, fanaticism, ignorance and barbarism of the Turks, whose habits, manners and customs, form a striking feature in the variegated history of mankind.

As the laws of Islamism enjoin frequent ablutions, and in warm climates the practice of bathing is generally deemed a very high enjoyment, the conduct of the Turks, in neglecting, defacing or destroying many of the cisterns and baths, exhibits a degree of barbarism that resembles the freaks of insanity. For whatever may be the rank of a married woman the injunction for her attendance at the baths, every Thursday, is peremptory; besides, that strict attention may be paid to this rite of their religion, several of the baths are gratuitously open for use, so that even poverty is not allowed to be an excuse for neglect. In Constantinople the better kind of houses generally have a commodious bath; but it is to be lamented that by the too frequent practice of bathing

many injure their health, by inducing debility that eventually proves fatal in its consequences. At a late period, the public baths alone have been stated as amounting to 130 within the walls of the city;* but the indolent dispositions and habits of the Mahometans preclude the enjoyment of such pleasures as the gymnastic and other exercises of ancient Rome, and therefore no provision is made for their indulgence.

The care and management of the water-works at Constantinople is confided to about 300 Turks and 100 Albanese Greeks, in whom the profession may be deemed almost hereditary. Though the fountains are so numerous as to be in nearly every street, yet a great number of people obtain their water from persons, who earn their subsistence by carrying it about the city in leathern buckets for sale. Such a practice indeed is generally prevalent in all the principal cities and large towns of the European continent, though in many of them, the use of larger vehicles is adopted, containing one or two hogsheads. These water-carts are very common; but the annoyance arising from the cries of the water-vendors in the streets, is a subject of serious complaint by travellers, who have not been accustomed to them. Though the reservoirs at the mountains of Belgrad, are calculated to afford an abundant supply, yet it has been estimated that the average daily quantity afforded to the inhabitants of Constantinople, amounts only to about four gallons for each individual.

Notwithstanding the abundance of water usually obtained from the mountains at Belgrad, instances of long periods of dry weather have sometimes occurred, to create the most serious apprehensions of a deficiency;

* *Dallaway's Constantinople*, p. 189, &c.

and a recent traveller relates a case which happened during his residence at Constantinople, when no rain had fallen for six months. "The coming of rain," he observes, "is indicated here, as in Syria, by a small dark, dense, circumscribed cloud, hanging over the Euxine or Propontis. On such occasions, a dervish stands on the top of Giant's Mountain, and when he sees a cloud, he announces its appearance, like Elijah from the top of Mount Carmel. One day I climbed to the same place, and saw the dervish on the watch, and 'I looked towards the sea, and beheld a little cloud rising out of the sea, like a man's hand, and gat me down that the rain stopped me not.' In effect it immediately followed, and the Turks were relieved from a very serious cause of anxiety; because for 700,000 people, the reservoirs then contained only fifteen days supply." *—Such a circumstance could not be otherwise than alarming, because they had no other resource to which they could apply in exigencies of the kind; and the same writer remarks that "if the Russians ever approach and lay siege to Constantinople, a supply of water will be their first object. In its present state, if the besiegers cut off the communication with the reservoirs, (which it is presumed they would do in the first instance), the city could not hold out for a week." The possibility of such an emergency must give rise to serious reflections; and delightful as may be its situation, the contingency mentioned above renders it inferior, in that particular point, to all the other great cities in Europe, which generally have either large rivers, or copious springs, in their vicinity; besides the supply of water to some of them is aided by various contrivances of science and art. The present Sultan seems to

* *Walsh's Travels.*

have a propensity to encourage improvements; and perhaps, therefore, a reasonable hope may be indulged, that the inhabitants of Constantinople will enjoy those advantages, which in Great Britain have conduced, not only to diminish the casual evils of dry seasons, and frequent fires, but likewise to augment the conveniences and pleasures of human life.

CHAPTER XIV.

Remains of Roman Aqueducts in different countries. Segovia, Seville, Nismes, Metz, Fourvieres, Rungis, Paestum, Puzzuola, Pisa.—Solomon's Aqueduct near Bethlehem, &c. Antioch, Hamah, Tyre, Mytelene, Salamis, Tunis, Caserta, Versailles.—Aqueducts in Great Britain;—Barton Bridge, Valley of Kelvin, Cysylte, Chirk, Valley of Slateford.—Magnificent Fountains at Rome;—Pauline, Aqua Felice, Trevi, Piazza Novana, Circus of Flora, Temple of Vesta; Colonnade of St. Peter's, Piazza di Spagna, Gardens of the Doria Family. Conclusion.

Admirable as may be the elaborate contrivances for supplying Rome and Constantinople with clear and salubrious water, other countries also possess magnificent works of a similar kind, demonstrative of the lofty conceptions of the Romans, as well as their extraordinary exertions to realize their schemes. Indeed they left some memorable traces of their genius, enterprize, and skill, in all the nations to which their power extended and continued for a considerable length of time. Notwithstanding so many ages have elapsed since these useful edifices were first constructed, yet several still endure, affording the advantages originally contemplated.

Spain possesses one of the noble aqueducts constructed by the Romans. It is employed for supplying Segovia,

and its water actually flows through the city, having its course above the greater number of the houses. The length of this structure is about 2,400 Spanish feet, and its greatest height about 100 feet. It is formed by a double row of arches, composed of large square stones, placed together without cement; and over these the channel for the water is constructed with large oblong flat stones, having a wall on each side. The number of the lower range of arcades is forty-two, and they have a width of fifteen feet by a height of sixty-five; but the upper range of arches consists of one hundred and nineteen, with a height of twenty-seven feet, by a breadth of seventeen, and the transverse thickness of the piers is eight feet. This fine structure is remarkable for its solidity and excellent masonry. Fortunately this admirable relic of antiquity has equally withstood the desolating violence of barbarians, and the powerful attacks of inclement seasons, through a long series of ages. The design is strikingly light and beautiful; and its aspect has not only afforded gratification to architects, but puzzled antiquarians, who have entertained different opinions with regard to the epoch of its construction,—some ascribing the merit of erecting it to Trajan, and others to Hercules, for it has no inscription to determine the period when it was built.

The city of Seville is chiefly supplied by a great aqueduct which the Romans probably contrived and executed, though the numerous repairs of the structure, at different periods, have so far defaced and obliterated the style of its architecture, as to induce some persons to ascribe its construction to the Moors. In its present state the arches composing it are not only unequal in their dimensions, but rugged in external appearance; and even its line of direction is crooked. Inattention and neglect have also

concurred to deteriorate its condition and hasten its decay; for the channel has been suffered to become so very leaky, that the water which escapes has actually formed a rivulet below it. Lamentably defective, however as may be the state of this extensive aqueduct, its utility is evident from its conveying an abundant supply of water from Alcala, which is many miles from Seville, where almost every house in the place has the advantage of receiving it, excepting such as are situate in the districts supplied by the pipes from the fountain belonging to the Archbishop. In order to obtain the water at Alcala, the rocks are perforated in various directions for a considerable length under ground, so that every little stream or spring may be intercepted, and the water from each conveyed into the channel of the aqueduct. The quantity thus collected is very considerable; besides the current has so much velocity as to render it applicable to the operations of several mills, in the progress of its course.

The Romans likewise constructed several magnificent aqueducts in France, the object of one being the supply of Nismes, from the sources of the Eure and Airon. Those parts of the structure which have resisted the ravages of time and the elements, evince the extent and importance of this great work; for the bridge over the Gard probably surpasses any erected during the continuance of the Roman authority in Gaul. It consists of three tiers of arcades placed one above another; the lowest is formed by six arches; the second by twelve; and the third has thirty-five. The latter contained the channel which conveyed the water across the valley, at an elevation of more than 150 feet above the level of the water in the river. M. Genieys, an eminent French engineer, estimated that the quantity of water conveyed by this aqueduct amounted to more than 63,244,000

litres, or about 465,277 hogsheads, in every twenty-four hours.

Metz is also distinguished by a stupendous aqueduct of Roman construction, and the great number of arcades of which it formerly consisted, attest its original magnitude. Though the breadth of the river Moselle is very great at that city, superb and lofty arches were erected to convey the water over it; and some of them still remain at the distance of two leagues from Metz. The workmanship of this structure was likewise so excellent, and the cement employed united the materials composing it so firmly, that excepting parts which have been forced away by large masses of ice, during impetuous floods, it has resisted the effects of inclement seasons through many centuries. During the time that the Roman power existed in Gaul, other aqueducts branched off from these arcades to convey water to baths, and also to a place where the representation of a naval engagement was exhibited. For this latter purpose the water of the river Gorze was likewise conducted by tunnels formed of hewn stone, and terminating at a great reservoir, peculiarly adapted for exhibiting a sea-fight.

In the reign of the Emperor Claudius, an aqueduct was formed to convey the water from Fourvières to the highest part of the city of Lyons, and this structure was remarkable for the beauty and boldness of the design. As valleys of great depth were in the line of its course, if arcades had been erected with a view to preserve uniformity in the flowing of the water, such enormous and expensive works would have been requisite, as might have prevented the execution of the project; consequently, instead of an elevated canal, leaden pipes were substituted, forming a syphon: thus the plan was realized with much less labour and expense.

According to M. Genieys, during the short residence of Julian at Paris, in the year 360, an aqueduct was constructed for conveying the water from Rungis to the palace of the baths; and that another subterranean aqueduct likewise commenced on the heights of Chaillot, at the mineral springs, whence it crossed the Champs-Elysées, from a part of the garden of the Tuilleries, and probably terminated towards the middle of the place now occupied by the garden of the Palais Royal. Besides, in 1781, at the northern extremity of the latter, about three feet below the surface of the soil, a square reservoir of Roman construction was discovered, as well as some medals of Aurelian, Dioclesian, Posthumus, Magnentius, Crispus, and Valentinian I., which lead to the inference of the basin being constructed in the reign of the last emperor.

The remains of various other aqueducts still exists in Italy, as well as in distant countries which the ancient Romans subjugated to their domination, and therefore formed provinces of the empire, when their widely extended conquests displayed the ambitious aim of becoming the masters of the civilized world. Among the magnificent ruins of Paestum and Puzzuola, in the kingdom of Naples, some large portions of grand aqueducts form conspicuous and attractive objects of attention. In the vicinity of Pisa, the remains of another of these structures are still to be seen; but that city now receives its supply of water from one of modern construction, consisting of 1000 arches; and though its original purpose was the advantage of Pisa alone, it has since been extended to Leghorn.

Though the aqueducts constructed for the supply of Rome, and other parts of Italy, are unparalleled both for grandeur and extent, similar contrivances have been

adopted in different countries, for the purpose of conveying water to the principal cities. Maundrel, in his travels to the Holy Land, relates, that at a short distance from Bethlehem there existed the remains of an aqueduct, the building of which was attributed to Solomon, and that anciently it conveyed water from his *pools*, or reservoirs, to Jerusalem. Another traveller who visited the same place, at a subsequent period, and examined these structures more minutely, states, that the aqueduct is "built on a foundation of stone; the water runs in round earthen pipes, about ten inches in diameter, which are cased with two stones, hewn out to fit them, and they are covered over with rough stones, well cemented together; the whole being also sunk in the ground on the side of the hills, so that in many places nothing is to be seen of it."* It commences at rather more than six miles distance from Jerusalem, taking a circuitous course round the hills, and afterwards through a plain on the surface of the ground till it reaches the city. Solomon is represented to have had a house and gardens in the vicinity of the pools, where there was what was called the *sealed fountain*, from which the conduit conveyed the water.

The *pools* in the vicinity of Jerusalem are quadrangular, and vary in dimensions, having a width of from 200 to 300 feet, by a length of from 300 to 400 more. They are formed partly by excavating the earth, and partly by the erection of a wall, which is about seven feet thick, at the lowest end of the reservoir, but only three at the other. The whole are surrounded with a similar wall, and each has a different elevation; the highest reservoir being the shallowest, the second rather deeper, and dug as deep as it could be without cutting away the rock; but the steps

* *Dr. Richard Pococke's Travels.*

to it are hewn out of the rock. This basin has a considerable depth, the wall consisting of eleven tiers of stone, two feet or more in thickness. The third or lowest part has a place for bathing; and a stream flows below it, in a covered channel, from a fountain, which is situate in a small valley. Near to the lower end of the latter reservoir there is a descent by steps, under which a grotto has been formed containing three outlets, which can be opened or closed as circumstances may require; and from one of these the water runs into the great canal below. It has been conjectured that these reservoirs were intended to receive the superabundant water from the neighbouring fountains, and therefore adapted to afford a supply of water to the aqueduct when any of them failed.

The *sealed fountain* is situate on a declivity, opposite to the pools. It is contained in a quadrangular inclosure, which has a square basin supplied by four streams. As the whole is arched over, the structure has not any external indications of its object, and the water flows from it by two apertures at one end. It is presumed that these contrivances are referred to by Solomon, where he compares his spouse to "a garden enclosed, to a spring shut up, and a fountain sealed."*

In Asia Minor there exist many remains of aqueducts —the works of an early period for supplying the wants of the inhabitants. Several of these are in the vicinity of Antioch in Syria, and one of them is not only large, but also rather peculiar in its construction. Though lofty, and in some parts about 200 feet high, it consists chiefly of solid walls, excepting a few arches in the upper part;— two near the middle are ranged one over the other, exhi-

* *Canticles*, chap. iv. v. 12.

biting a tier of three arches, but the whole are narrow. Those in the neighbourhood have, however, arches of large dimensions, one of them being formed by five, though others have only a single arch to convey the water across the valleys; and great labour seems to have been employed, to direct the produce of the various springs within some miles of the town, for supplying the inhabitants.

At the town of Hamah, in the same province, the water is raised from the Orontes by wheels, to which square buckets are attached, and moved by the current of the river. Several of these wheels have a diameter of nearly forty feet, and elevate the water nearly to the upper part of their rim, where it is discharged into wooden troughs, which convey it to the aqueducts. Some of the latter consist of very high and well-built arches; but a considerable portion of the water-course to the towns is along the sides of the hills.

Tyre, the name of a place often occurring in history, possesses also its fountains and aqueducts, the construction of which has, likewise, been ascribed to Solomon, who is said to have made "gardens, and orchards, and pools of water." Indeed, such works appear to have greatly interested him, for they are frequently the objects of his similes: the fountain from which Tyre is principally supplied, being supposed to be that designated in his Canticles, as "a fountain of gardens, a well of living waters, and streams from Lebanon."*

These springs rise about half a mile from the sea, and are inclosed by a wall about fifteen feet high; two other springs in the neighbouring mountains also supply a considerable stream of water to the same point. The height

* *Canticles*, chap. iv. v. 15.

of the reservoir at the source is sufficient for the water to flow from it along an extensive aqueduct to Tyre; and its abundance occasions the application of the current to the working of several mills. The aqueduct is constructed on arches commencing at the reservoir.

Numerous as are these devices, and all having the same object, their contrivers seem to have been studious to vary their form and external appearance. At Mytelene, one of the Greek islands, a magnificent aqueduct conveyed the water across a deep valley; it is about 300 feet long and eighty feet high, consisting of three tiers of arches for some distance; but although the principal part of the structure has been formed of a species of grey marble with a rusticated exterior, yet the upper arches are turned with bricks. Near to Salamis are the remains of an aqueduct, having pointed arches in the Gothic style. In her letters, Lady Wortley Montague mentions the remains of an aqueduct, six miles from Tunis, which, in former ages, conveyed the supply of water to Carthage, over valleys and mountains for a length of forty miles. The stones employed for its construction are not only of a prodigious size, but highly polished, and exactly fitted to each other, so that very little cement was used to join them together.

Amongst the remarkable modern works distinguishing the classic region of Italy, may be enumerated the aqueduct for supplying the palace of Caserta, situated in a northerly direction from the city of Naples. Probably this structure is one of the finest of its kind constructed in that country since the days of the ancient Romans. Its extent and elevation vie, in several particulars, with some of the noblest of their magnificent edifices. At some places its course passes through mountains, and at others over deep valleys. The water is conveyed across

the valley of *Maddaloni*, by a triple range of lofty arches, extending the length of 2000 feet; some of them having a height of 200 feet. The first tier consists of nineteen arches;—the second of twenty-seven;—and the third of forty-three; but the width and depth of the channel have nearly the same dimensions, being respectively about four feet. The water supplying it rises in the vicinity of Mount *Taburnus*: it is very pure, and flows along the aqueduct to a reservoir at the summit of Mount *Gazzano*, whence it is precipitated down a declivity into a plain below.

The aqueduct, constructed by order of Louis XIV., for the purpose of conveying water from the River Bucq to Versailles, is a fine structure, and has 242 arcades. Its length is 7000 fathoms. In France several elaborate works of the same kind have been erected in the course of the celebrated canal of Languedoc.

The forming of various canals in Great Britain for facilitating mercantile intercourse between different districts, has also given rise to the contrivance of some ingenious aqueducts, for the purpose of conducting their channels over rivers and valleys. That devised by Mr. Brindley to carry the channel of the Duke of Bridgewater's canal over the River Irwell, at Barton Bridge, was one of the first structures of its kind in this country. It consists of three arches, the middle one having a width of sixty-three feet, with a height at its centre of thirty-nine feet above the surface of the water in the Irwell, and then exhibited to Englishmen the novel spectacle of vessels sailing over a river, as well as in it at the same time. Another, designed by Mr. Rennie, conveys the Lancaster canal over the river Lune: it is formed with five arches, each having a span of seventy-two feet, with a height of sixty-five. This engineer also constructed an aqueduct comprising four arches, with the width of

seventy feet, and the same height, for conducting the Forth and Clyde canal across the valley of Kelvin.

Improvements in our manufacturing arts have, however, led to the adopting of a different mode of constructing such useful contrivances; and, instead of employing ponderous heaps of massive stones or bricks, united by strong cements, the material selected has been *iron.* The first attempt to use it was made by Mr. Telford, at Cysylte, for the purpose of conveying the Ellesmere canal over the river Dee, in the vale of Llangollen. The length of the aqueduct is about 1000 feet, and it consists of nineteen arches, each having a span of forty-five feet, and the height of the centre arch is 128 feet above the river. The channel for the canal is formed with strong cast iron plates, and it rests upon arches formed with cast iron ribs, the arches being supported by strong stone pillars, which taper slightly as they ascend from their bases. The height of the pillars supporting the four middle arches, is 115 feet; each having a diameter of fifteen feet at the base, and the arches spring from their summit. At Chirk, the same canal has also a similar aqueduct, about 600 feet long, consisting of ten arches of forty-two feet span, having a height of sixty-five feet above the level of the water in the river.

Near to Edinburgh an elegant aqueduct has been constructed; and its object is the conveyance of the Edinburgh and Glasgow canal across the valley of Slateford. Its length is about 500 feet; and its height above the level of the river about seventy feet. It consists of eight arches, each with a span of forty-five feet. Different public works have the advantage of similar structures, though less in their dimensions; but the preceding enumeration comprises the most striking edifices of their kind in Great Britain. The construction of aqueducts being

analogous to that of bridges, if the great cost of several of the latter be considered, some notion may be formed of the amazing sum which, in modern times, would be requisite to construct aqueducts equally extensive, ponderous, and magnificent, with those of the Romans. Waterloo Bridge, over the Thames, occasioned the expenditure of more than 1,000,000*l.*;—the expense of erecting the New London Bridge has been more than twice that amount, hence it may be fairly inferred, that a sum equalling in magnitude our national debt—the result of ages of warfare—might perhaps be found inadequate for accomplishing such elaborate works as some of the Roman aqueducts.

Reverting, however, again to Italy, it may be remarked, that, if during the most distinguished eras of the Roman state, the aqueducts conduced to the luxurious enjoyments of the wealthy and powerful, yet in modern times, the residents of Rome have also found them particularly advantageous, by their furnishing occasions for the cultivation of those elegant arts, which, in a peculiar manner, call forth the energies of genius, and the exercise of refined taste, in realizing and decorating her productions. Qualities of this kind appear conspicuous in several of the numerous fountains which adorn that celebrated city; and the most intellectual and accomplished professors of sculpture and architecture, have happily united beauty and grandeur, in the construction of many such admirable edifices. These structures are also characterized by great diversity of design, as well as skilful execution; hence, a concise description of several of them may, perhaps, form an interesting and appropriate conclusion to this detail.

The largest structure of this kind in Rome, is that denominated the *Pauline* Fountain, which was built by

order of Pope Paul V., with the materials of Nerva's Forum. This spacious edifice is situate on the highest part of the Janiculum hill, and Dominica Fontana, and Carlo Mederno furnished the designs for its construction. The front is adorned with six Ionic columns of red granite, on which an attic has a tablet containing an inscription with the pontiff's arms placed above it. Between the columns the spaces are open, and from these arcades the currents of water flow with a loud noise, and in great abundance. The apertures on the sides are smaller than the others, and in each of those is placed a dragon spouting water into the spacious magnificent marble basin below. This fountain is furnished with water by the aqueduct called *Aqua Paolo*, which has its origin thirty-five miles distant from Rome; and it runs from the basin, in a very large stream into several canals, whence it is employed to work various corn, paper, and other mills, as well as to supply fountains and fish-ponds in the gardens and palaces of the opulent.

Near to the baths of Dioclesian, and in the square of the *Termini*, stands the fountain of the *Aqua Felice*. The edifice is not only elegant but fanciful, and it has three arcades ornamented with four Ionic columns of granite. The middle arcade has a colossal statue of Moses, causing the water to issue from the rock; and at the sides are two basso relievos, one representing Aaron leading the Israelites to the miraculous spring, and the other Gideon selecting the soldiers to enlarge the passage for the water, which flows in great abundance through three apertures into marble basins. The sides are adorned by four marble lions, with the water issuing from their mouths: two of these are formed of white Grecian marble, and the other two of black granite. The latter are Egyptian workmanship, and covered with hieroglyphics.

This noble fountain was erected from a design of Cav Fontana; by the order of Pope Sixtus V., and its supply of water is obtained twenty-two miles from the city.

Another of these fine structures is that called the *Fountain of Trevi*, in which boldness of design, and elegance of architecture are admirably united. The erection of this very magnificent edifice commenced during the pontificate of Clement XII., who repaired the aqueducts. Niccolo Salvi designed the grand front, but the work was completed under Clement XIII., who decorated it with statues, basso relievos in marble, and different columns of the Corinthian, Ionic, and Composite orders. In the centre is a statue representing Oceanus, standing in a car, drawn by two large sea-horses, guided by Tritons. One of the horses appears furious and impatient, whilst on the contrary the other is exhibited as calm and placid, so that both are symbolical of the tempestuous or tranquil state of the sea.

> " Bounding to light, as if from ocean's cave,
> The struggling sea-horse paws the lucid wave,
> While health and plenty smile, and Neptune's form
> Majestic sways the trident of the storm."

A statue, designating Abundance is placed at the right of Oceanus, and on the left another emblematical of Health. The basso relievo, which adorns the right side, portrays the Emperor Trajan, contemplating a plan of the fountain; and that on the left exhibits a girl showing to some soldiers, the spring that supplies it with water. Various other sculptures decorate this superb edifice; and at the top of the principal front are two figures of Fame, supporting the arms of the Pope. Its supply of water is furnished by the Aqua Virginia; and it flows in very large streams from three arcades. The cost of constructing this splendid and useful fountain was great:

but it ranks among the most interesting objects conspicuously embellishing the city of Rome.

The *Piazza Novana* has a very noble fountain standing in its centre. It is composed of a large circular marble basin seventy-nine feet in diameter, in the middle of which is placed a rock of square form with apertures at the sides. The figure of a lion adorns one side, and that of a sea-horse another. From the base to the top of the rock, the height is about fourteen feet; and on its summit stands an Egyptian obelisk formed of red granite, fifty-five feet in height, and covered with hieroglyphics. At the four sides of the rock are colossal marble statues, which designate the four great rivers in the different quarters of the world: viz. the Danube, the Nile, the Ganges, and the Plata: and from these statues the water flows in copious streams to the spacious basin below.

> " The Nile and Ganges pour the silver tide :
> La Plata too, and Danube's streams unite
> Their liquid treasures, copious, clear and bright."

During the summer, it is the custom occasionally to permit the water to overflow the whole square, for the entertainment of the people; and on midsummer's eve persons amuse themselves by wading and driving through the flood. This practice has sometimes been attended with fatal accidents, and not only men but horses have actually been drowned in the attempts to pass it in carriages. In the month of August the area of the square is likewise filled with water for the purpose of amusement.

The same square likewise contains two other fountains, one of which consists of a capacious marble basin, having at its centre a Triton holding a dolphin by the tail; and on the margin of the basin are four heads with the same number of Tritons that spout the water from their

mouths. The other fountain has not any remarkable characteristics to entitle it to peculiar attention.

Where formerly stood the circus of Flora is now the site of the Piazza Barberinni, which has two fountains to embellish it:—one of them being composed of four dolphins supporting a large open shell, with a Triton in the middle ejecting water to a great height. The other is fanciful, being also formed of an open shell, from which three bees throw out the water.

In the vicinity of the Temple of Vesta stands a handsome fountain, having a capacious basin, in which some Tritons support a large marble shell. From the centre of the latter, the water spouts to a considerable height, and then descending flows over its margin into the basin beneath. Some fine fountains adorn the magnificent colonnade in front of the Cathedral of St. Peter. The *Piazza di Spagna* has likewise for its embellishment, a fountain in the form of an antique boat.

Besides the structures described above, there are a great number of other fountains which evince much diversity of taste and ingenuity in their contrivance. But at the different villas of the opulent, the abundance of water is rendered subservient to amusing as well as useful purposes, and several of them are rather singular. The description of one will convey some notion of what is common to many of them.

The delightful promenades, groves, and gardens belonging to the Doria family, are interspersed with fountains of various forms; besides having a beautiful lake with waterfalls. Statues, antique basso relievos, and small fountains adorn a kind of amphitheatre, where a circular edifice contains the marble figure of a faun holding a flute, on which it seems to play different airs: the music, however, is produced by a machine resembling

an organ in its construction, and motion being given to it by the flowing of the water from a cascade.

Perhaps the few instances recited above will suffice to demonstrate the different modes employed at Rome, for calling into exercise genius, fancy, and taste, to diversify the public edifices concerned with its abundant supply of water; thus rendering them subservient to magnificence, entertainment, and utility. Whilst John Dyer resided there, he viewed these celebrated fountains with the mingled feelings of the painter and the poet; hence, associating them with other interesting circumstances, they furnished the materials for one of his most striking and pathetic delineations.

" The pilgrim oft,
At dead of night, 'mid his oraison hears
Aghast the voice of time, disparting towers,
Tumbling all precipitate, down-dashed,
Rattling around, loud thundering to the moon;
While murmurs sooth each awful interval
Of ever-falling waters; shrouded Nile,
Eridanus, and Tiber with his twins,
And palmy Euphrates: they with dropping locks
Hang o'er their urns, and mournfully among
The plaintive echoing ruins, pour their streams."

Ruins of Rome.

CHAPTER XV.

Paris: means devised for procuring Water for the use of its Inhabitants. Aqueducts; Arcueil, Prés-Saint Gervais, Belleville. Henry IV. The Samaritan Pump. Plan to supply from the Seine: its failure. Unsuccessful project of Messrs. Perier. Schemes for constructing an Aqueduct by M. de Parcieux; Perronet and Chézy; Defer de la Noverre. Napoleon. Canal de l'Ourcq; M. Girard, engineer for its construction. Commission of Engineers. Company of Englishmen propose to supply Paris. Compte de Chabrol employed to inspect the Water-works at London. M. Mallet's examination of the principal Establishments of England and Scotland; his project to supply Paris. Commission consisting of M. Prony, &c. Improved Plan. Prospectus for realizing it. M. Mallet's reflections upon the superior advantages of Great Britain. Methods of supplying Paris. Filtering Establishment. Proposal of Messrs. Lee and Taylor to Louis Philip. Remarkable Fountains:—the Innocents, Popincourt, Military Hospital, Hospital of Invalids, Dessaix, Place du Chatelet, Grenelle, School of Medicine, Leda, St. Sulpice, the Elephant.

THE means employed, during different eras, for affording a supply of water to the capital of France have been various; and among others for this purpose, several aqueducts were constructed,—for instance, those of Arcueil, Prés-Saint Gervais, and Belleville. Though the present aqueduct of Arcueil is a modern structure, one formerly existed having the same designation, but it was totally destroyed by the Normans in the ninth century. The water for its purposes was derived from sources in the vicinity of the village of Rungis, and even at some distance from it, as appears by the channels that have been discovered.

The aqueduct of Prés-Saint Gervais originally belonged to the Abbey of Saint Laurent, situate at the foot of Montmartre; but the precise period of its formation is unknown, yet its antiquity appears evident from the ruins having no resemblance to those of the ancient aqueduct of Arcueil. The hills of Romainville, Bruyeres, and Menil-Montant supplied it with water, which being collected in a reservoir situate at the village of Prés-Saint Gervais, was thence conveyed to Paris by leaden pipes.*

The aqueduct of Belleville commenced at the summit of that village, and terminated at the foot of the hill on which it is built. Its exact origin has not been ascertained, but from its having supplied a fountain within the boundary, it is supposed to have been constructed at the expense of the rich Monastery of St. Martin. An inscription on a small building connected with it records that the aqueduct was repaired in 1457, and this circumstance indicates the probability of its having been erected several centuries prior to that period.

As Paris increased in magnitude and population, the monasteries were gradually included within its walls; and thus circumstances probably imposed the necessity of the public participating in those advantages with respect to the supply of water, of which the use had previously been exclusively possessed by the religious establishments. Eventually, however, either by purchase, or other means, the aqueducts of Prés-Saint Gervais and Belleville became the property of the city of Paris; and consequently the distribution of the water was regulated by the direction of its municipal authorities. For a long

* "*Recherches sur les Eaux publiques de Paris,*" par M. Girard.

period, these two aqueducts alone supplied the few fountains which then existed on the right side of the Seine; for on the left, none at that time had been erected.

It is related that Henry IV., in 1609, entertained the idea of restoring the ancient aqueduct of Arcueil, with the view of furnishing an increase of water to the southern districts of Paris; and that some researches for discovering the old conduits were actually made in the plain of Rungis. However it was soon ascertained that the preferable mode of effecting the object would be the construction of a new aqueduct to convey the same water; and this undertaking was begun in 1613, under the regency of Mary de Medicis. It was completed in 1624, having occupied nearly twelve years in its execution from the designs of Jacques de Brosse, an eminent architect, and this fine structure evinces both his talent and taste; —the same person furnished the design for the Louvre.

From the progressive increase of the population of Paris, and the operation of some other causes, the quantity of water supplied by the aqueducts of Prés-Saint Gervais, and Belleville, gradually proved very inadequate to the wants of the inhabitants, and therefore recourse to means for obviating the deficiency became absolutely indispensable. This led to an attempt by a Fleming, named John Lintlaer, who constructed a pump to which motion was given by the current of the Seine, and it raised the water from the river above *Pont Neuf*, whence it was conveyed to the Louvre and Tuilleries. It was erected by order of Henry IV., and received the appellation of *The Samaritan*, from the gilt leaden figures which decorated its front. As this experiment was successful, it suggested the construction of two others of a similar kind upon *Pont Notre Dame*, one of which was com-

pleted in 1670, and the other in 1671.* Useful as these engines might be, they effected their object in an imperfect manner, besides frequently requiring repairs, so that it became necessary to renew them every twenty-five years.

About the year 1735, two persons proposed a plan for supplying Paris, by a method similar to that practised in London. The object was to raise water from the Seine by the power of steam-engines, and distribute it to all the houses of the city by means of pipes; but the details of the scheme were either too little known, or imperfectly understood for its advantages to be properly appreciated, and consequently the proposition did not receive any encouragement. Another attempt was made in 1778, when Messrs. Perier obtained authority to form a company for the purpose of supplying Paris from the Seine; and although in the execution of their plan they unfortunately had to encounter various obstacles, yet the erection of the two steam-engines at Gros-caillou and Chaillot formed a part of their works. The shares of the company, like many others embodied for the same purpose, greatly fluctuated in price, so as gradually to be deemed of very trivial value; and the two steam-engines eventually became the property of the city of Paris. Unsuccessful, however, as the enterprize proved to those who engaged in it, the utility of these machines has been demonstrated by their use affording a large supply to several fountains, and other establishments.

Considerable as was the quantity of water furnished to

* The machinery at Marli had, for some time, been employed to supply water to the numerous fountains at Versailles. Mr. Beighton, who gave an account of the London Water-works in 1731, represents those at Marli to be much inferior in their construction.

Paris by the different hydraulic machines and other contrivances, nevertheless, the supply to the public fountains was defective and irregular, from the frequent interruptions occasioned by the repairing of the pumps, or accidents occurring to the steam-engines. The insufficiency arising from such circumstances alone, sometimes occasioned very serious inconvenience to the inhabitants; and to obviate them various persons proposed different plans, which aimed at being more simple in their general operation, and less liable to be often ineffective from casualties.

In 1762, M. de Parcieux, a Member of the Academy of Sciences, projected an aqueduct to procure water from one of the small rivers in the vicinity of Paris, and convey it to the city. On this occasion the Yvette was deemed to be the preferable source, because the river rises near to Dampierre, and discharges itself into the Orge at Savigny, which would allow the water to flow into a reservoir, six feet higher than that of Arcueil. It was estimated that the quantity derivable from this stream, would be four or five times that which the old aqueducts and hydraulic machines usually supplied; but no attempt was made to realize this useful project, though its advantages were afterwards distinctly pointed out by Messrs. Perronet and Chézy, in 1775, by accompanying their representations with appropriate plans, and very satisfactory calculations of the expense of its execution. The same scheme with some modifications was again propounded in 1782, by M. Defer de la Noverre, who offered to undertake the accomplishment of the work, on such conditions, that the city of Paris would not have been required to advance the pecuniary means. After various delays in the proceedings, in 1788, the proper authority for making the canal of Yvette was obtained, and its line actually traced, but

new obstacles interposed to prevent its progress;—the Revolution occurred, and the works were suspended never more to be resumed.

Notwithstanding different ingenious and enterprising men experienced disappointments, the subject was so interwoven with the common exigences and enjoyments of the community, as to be constantly urged upon attention. Consequently, among the many useful works projected during the time that Napoleon presided over France, the Canal de l'Ourcq may be named as a conspicuous instance, inasmuch as its principal object was to afford a larger supply of water to Paris. This important scheme is attributable to M. Girard, the engineer, to whose skilful superintendence its execution was confided. The decree for commencing the work had the date of 1802, though a diversity of circumstances either retarded, or suspended the operations for its completion till a very recent period. According to the original estimate, the additional quantity of water furnished from this source would amount to more than 670,000 hogsheads daily, and thus supply abundance for every purpose.*

This admirable contrivance for augmenting the supply of water to Paris, commences at the river Ourcq, about sixty miles distant from that city; but in its course the waters of the Grisette, the May, the Therouanne, and the Beuvronne, flow into its channel, which terminates in a spacious reservoir, constructed near to the north-eastern extremity of the Barriere de la Villette. The length of the basin is about 3,660 feet, by a breadth of 366 feet, with a depth of 7 feet. Its banks are ornamented with a double row of trees, which render it a very pleasant promenade; and two other canals are also connected with

* *Rapport sur le Canal de l'Ourcq.*

it, one of them passing through the suburbs to the arsenal, and the other to Saint Denis.

Several delays having occurred in executing this useful project, the circumstances occasioned a commission to be appointed in 1816, consisting of engineers, who subsequently made a report to the municipal authorities of Paris of the state of the Canal de l'Ourcq at the time, as well as an account of the different works which would be necessary to complete it. This document imparted information of peculiar importance, by exhibiting the diversity of advantages contemplated in its accomplishment, inasmuch as it would convey a large quantity of water to one of the most elevated situations adjoining the city, and contribute to its embellishment, salubrity, and cleanliness. Besides, from the abundance flowing to all the principal places, it would thus afford a more ample security to property, by facilitating the means for arresting the devastations of fires.

Another interesting fact has a reference to this object. A few years prior to the above report being made, a company of Englishmen actually proposed conditions, and endeavoured to obtain permission, to undertake the distribution of water to the inhabitants of Paris, by the method practised at London, and other populous places in Great Britain. In 1814, the same company engaged Mr. W. C. Mylne, the experienced and skilful engineer to the New River Company, to visit Paris, in order to collect the necessary information for realizing their project, and consequently he resided there for some time, so that his observations and inquiries enabled him to form the plan which was sent to them in 1816. As this document elucidated the purpose of the contemplated enterprise, and rendered its advantages more obvious, the persons concerned in the proceedings became so earnest as to

occasion different propositions for carrying it into effect. The scheme of an agreement was even drawn up, and submitted to the consideration of the same commission that had been appointed to make a report upon the state of the Canal de l'Ourcq. Afterwards another commission selected from the municipal council likewise deliberated upon the plan, and in 1817 an estimate of its cost was finally arranged.

On this occasion the municipality of Paris proved themselves to be shrewd and skilful negociators, anxious to secure not only the present, but future interests of the citizens, for the conditions they proposed to the company were remarkably rigid. Besides reserving the right of enjoying the produce of the then existing establishments till the time when the new system should be actually finished and in complete operation, they required the company to pay 3,500,000 francs for the possession of the hydraulic establishments belonging to the city. Another stipulation proposed, that at the end of a certain period not only the property so purchased, but all the improvements made in them, should gratuitously revert to the city, as well as the entire works constructed by the company for distributing water to the inhabitants of Paris, with the whole of the revenue attached to them. Previous to commencing any of their operations, the company were also to present a complete scheme of the intended system of distribution, accompanied by plans and detailed estimates relative to every part of it, in order that the council of public works might inspect and scrutinize them. The professed object of the last condition was, that the authorities might be enabled to superintend and accelerate the completion of the works, so that the inhabitants might not experience any inconvenience. The scheme was, however, eventually abandoned, and it is not

improbable that the condition of allowing the company a temporary interest only in the undertaking, might induce them to avoid entering into an engagement necessarily requiring the expenditure of a large sum of money, though an adequate remuneration was uncertain.

Momentous as was the object, several years elapsed before any further effective attempt was made, either for improving or facilitating the supply of water to Paris; but in 1823 circumstances occasioned the municipality, and particularly the Compte de Chabrol, Prefect of the department of the Seine, to direct attention to the subject. This person possessed not only the science of an engineer, but perseverance and an enterprising disposition, being also anxious to extend the circle of his knowledge so as to enable him to benefit the community. Hence, he indulged a strong desire to visit and observe a country, distinguished by the great and useful works undertaken and accomplished during more than twenty years of a war, which had interrupted the communications between it and France. Though entertaining no repugnance to the scheme of Englishmen carrying freely the devices of their ingenuity, or the fruits of their experience into France, yet he determined on making a journey to England for the purpose of carefully inspecting the means employed to distribute water to the inhabitants of London. Habituated to observation, as well as having the requisite qualifications for attaining his end, he soon became acquainted with all the chief points of the system pursued, and likewise perceived the advantages which would attend its application to the city of Paris.*

Compte de Chabrol therefore visited England, and

* *Recherchés Statistiques sur la Ville de Paris, &c.*, par Compte de Chabrol, 1823.

when he returned to France, the result of his observations was communicated to the municipal council, and in August, 1824, they were disposed to renew their negociations with the company which had formerly proposed to supply Paris. However, on referring the business to the supreme authority, it was decided that no plan should be adopted, except by public competition; and this decision proved not only the cause of farther delay, but also led to more particular inquiries. In a short time afterwards, M. Mallet, chief engineer of the public works, was ordered to travel in Great Britain, for the specific purpose of minutely inspecting the contrivances at different places, so that he might acquire the requisite information to enable him to digest a comprehensive plan, founded upon the same principles, as well as sanctioned by the practical results of the great establishments at London, and other places in this country, for the distribution of water.

M. Mallet promptly proceeded to fulfil the duties of his commission, and he inspected the water-works at London, Manchester, Liverpool, Edinburgh, Glasgow, and Greenock. In the progress of his peregrinations he collected a variety of useful information for his purpose; and particularly acknowledged his obligations to the different engineers, for their liberality in furnishing him with various documents and numerous particulars, relating to the practical detail of the respective works under their superintendence. Having but little time allowed for his excursion, his observations were of course rapid, and perhaps in some instances imperfect, nevertheless, he was enabled to give to the municipal council a satisfactory statement, both with respect to the nature of the operations employed, and the amount of money which would be necessary to carry into effect any similar plan for the

supply of Paris. Hence, in March, 1825, he presented an outline of a project for the purpose, with an estimate of its probable expense, amounting to 24,000,000 of francs, but including in this sum 6,000,000 of francs for the public fountains.

The consideration of this preliminary production occupied the attention of the council during several months, and in the subsequent August, they requested M. Mallet to digest and draw up a plan that should not only be more complete, but be accompanied by appropriate explanations and details for its elucidation. Accordingly in February, 1826, he presented a minute and comprehensive scheme for generally distributing water from the Canal de l'Ourcq, for all the public, domestic, and other purposes that Paris seemed to require; at the same time he also delivered a memoir descriptive of all the works contemplated, and the cost of each separately, as well as thirty-four designs illustrative of his views. All the drawings were executed on a large scale to exhibit the mode of arranging the buildings, and the disposition of all the pipes in every one of the streets. The estimated expense of the whole amounted to 22,000,000 of francs;—prudential considerations prevented M. Mallet from introducing anything which experience had not authorized; and all the principal as well as minuter points were founded upon the practice that, for a long period, had been pursued by the establishments at London.*

M. Mallet's project had one remarkable feature deserving of particular notice. He proposed to construct *two* filters in which the water was to have an *ascending* motion, and both so connected with the aqueducts or mains,

* *Projét de Distribution d'Eau dans l'Interior de Paris*, par M. Genieys, 1827; et *Essai sur les moyens de conduire, elever, et distribuer les eaux*, 1829.

that each might furnish a regular supply of water, when one of them was either cleansing or required repairs. Three reservoirs were likewise to be constructed on situations of considerable altitude, as well as sufficiently capacious to supply the principal mains, and keep them constantly full, that they might be always readily available for the extinguishing of fires. Their respective sites were to be—one at Menil-Montant, another at Montmartre, and a third at L'Estrapade.

The scheme on which M. Mallet had bestowed so much labour and ingenuity was however destined to encounter delay. After its examination by various persons in authority, it was thence referred to a commission consisting of M. M. Prony, Tarbé, Lamandé, Lepére and Jousselin; and finally to the council for superintending the public works. The importance as well as the variety of its details gave rise to much discussion. The architecture, the mechanical and hydraulic contrivances intended to be employed, successively became the subjects of investigation and occupied a large portion of time and attention. Although the plan was generally approved, yet the idea was suggested to substitute the water of the Seine for the beverage of the inhabitants, instead of that from the Canal de l'Ourcq. This suggestion occasioned the devising of several modes for effecting its object; and the opinions of their respective merits were conflicting,—some being desirous that the same conduits should alternately receive the water from the Seine, and that from the Ourcq, whilst others urged the establishment of a distinct train for each. The last proposition seemed to have the preference, but it gave rise to three others, of which a succinct account will perhaps be desirable, because they show the interest excited by the subject.

One of the proposed plans contemplated a double dis-

tribution of the water of the Ourcq and the Seine, on the right bank of the latter river,—the principal part of the supply to be derived from the Ourcq, and at the same time employing a large conduit or main, with branch and service-pipes to convey such a portion of water from the Seine, as would be necessary for supplying private individuals on the left bank of the river, to which its distribution was to be solely confined.

Subsequently the proposition for applying the plans of distributing the water both from the Ourcq and the Seine again became the subject of consideration, when another scheme was propounded, having for its object to appropriate the water of the Ourcq to the system then in practice. To realize this M. Girard was urged to complete the project delineated and published by him in 1810, inasmuch as the works were in a very forward state, and would afford means to apply the new arrangements solely to the new mode of distribution. The last suggestion originated with M. Mallet; but before any decision was made the council desired him to ascertain the probable expense of executing the several schemes proposed. M. Mallet therefore made an estimate of the cost of the different projects; and having reduced all his calculations into a tabular form, as well as elucidated them with very clear explanatory notes, he presented the whole to the council for their consideration. In this ingenious and concise, yet comprehensive representation, the first place was occupied by the estimated cost and annual expense of the original scheme, for affording from the Ourcq two-thirds of the quantity of water necessary for the proper supply of Paris. But as other plans embraced the supplying of one-third of the water from the Seine, the statement also included the cost and contingent expenses of each respectively, as well as those for alternately supply-

ing from the Ourcq and the Seine, with another showing the expense of giving the supply exclusively from the Seine.

During the years 1827 and 1828 some other modifications of the general scheme were not only proposed and discussed, but the municipality of Paris even published an outline of their conditions, with the view of inducing persons who might be desirous to engage in such an enterprize, to communicate their remarks. Various observations and objections having been delivered, they were referred for examination to a committee of the municipality, assisted by M. Girard, and M. Mallet, with a view to a final decision. The two engineers having previously digested, as well as embodied on paper their own conceptions of what was requisite, they also presented their project for consideration, and it was determined that the three establishments belonging to the city should be made available, two of them being situate above, and one below, Paris, besides furnishing another site for a fourth establishment on the right bank of the river, and towards la Rapée.* M. Mallet accordingly composed a prospectus, comprising every thing intended to be proposed to persons who should be inclined to embark property in the undertaking, and containing the principles to guide their calculations for a contract involving very important considerations, both as regarded the city of Paris as well as the adventurers. This general plan indicated the various situations for the buildings, steam-engines, and reservoirs, whether already formed or to be constructed; the mode of distributing the water of the Seine; the places where it was to be taken; with the exact dimensions and directions of the mains and pipes of

* *Notice Historique, &c.* par C. F. Mallett, 1830.

different kinds for its distribution. Three separate drawings were likewise given, and these, being united to those accompanying the project for the canal de l'Ourcq, exhibited a connected view of all the circumstances relative to the whole of the project. Moreover, to render it as intelligible as possible, the prospectus was accompanied by an accurate description of every one of the different works comprised in the undertaking, with an estimate of the expense of executing them, and a separate statement of the price of the materials to be employed.

According to this scheme, the distribution on each side of the river was to be apportioned into high and low districts, and the services were also to be subdivided into high and low, the latter terminating at about ten feet above the pavement. It required four steam-engines to raise the water from the Seine; one having 100 horses' power at Chaillot; one of 60 horses' power at Gros-Caillou; one of 30 horses' power at la Garre; and one of 60 horses' power at la Rapée. The whole arrangement was admirably calculated to secure the most ample power for effectively and abundantly supplying every part of the city;—not a point seemed to have escaped the attention of the ingenious and scientific persons to whose consideration and management the business had been entrusted. Certainly an extraordinary share of theoretical and practical knowledge were united and concentrated to effect one great object. Indeed the plan appeared to be so complete and comprehensive as to fulfil the sanguine anticipations of the most enlightened citizens of Paris, and encourage the hope of its being realized.

As M. Mallet had carefully examined all the principal establishments of the kind in Great Britain, where he experienced every facility for obtaining information, concerning both their construction and details, they afforded

some aid to his own ingenuity for suggesting improvements. Skilfully and elaborately, however, as even this last plan had been formed, it received several modifications before it was printed in August, 1829. The following summary contains its principal provisions:—

It stipulated that about two-thirds of the whole quantity of water shall be taken from the Canal de l'Ourcq, about one-third to be raised from the Seine, and another small quantity in proportion to about one-eighteenth, from the sources of Arcueil, Près-Saint Gervais, Belleville, and Menilmontant;—the distribution to be effected by pipes placed under the public streets and roads; and the water so distributed, to be divided into two sections, each being quite distinct and independent on the other. The first section to comprehend the waters of the Ourcq and other sources; but the second, the water of the Seine only; and to prevent any mixture, or substitution of the water of the Ourcq, &c. with that of the Seine, the communication between the two sections to be made provisionally, in such a manner, that although either may be used in cases of great emergency, or accidents, yet not till permission shall have been specifically obtained for the purpose, from the municipal authority. Moreover, to ensure the strict observance of this condition, all the keys of the valves, or cocks connecting the different communications, were to be deposited with the agents of the magistracy, or trustees of the city. The whole of the water necessary for the public fountains, watering and cleansing the streets, and other purposes, being nearly two-thirds of the total quantity supplied, to be furnished gratuitously, under a penalty of five times the amount of the rate usually paid for the water. The low service to consist of a supply of the water of the Seine to all

parts of the city, to the height of three *metres* (nearly ten feet) above the level of the street; and those of the Ourcq, &c. to the same height, wherever the level of the basin of Villette, and the dimensions of the pipes, will allow it; but the low service alone to be considered obligatory on the part of the company, and the price of the water at the *Fontaines marchand* not to exceed nine *centimes*—rather less than a penny—the *hectolitre*. The exclusive privilege of supplying Paris to be secured to the company for the term of ninety-nine years, at the expiration of which the whole property of all the different works shall belong to the city. Such were the terms proposed for accomplishing an object not merely of great magnitude, but of the highest importance; and whenever so desirable and useful an enterprise shall be completed, it will afford to nearly 40,000 houses, an average daily supply of two and one-third *hectolitres*, or about sixty wine gallons of water for each, exclusive of the large quantity required for the public fountains and other establishments.

At the conclusion of an interesting account of various schemes, which, in conjunction with others, M. Mallet had been engaged to contrive for improving the supply of water to Paris, he indulged in some reflections evincing the fervour of his feelings, and the earnestness of his desires to realize so useful a project. Having for nearly five years sedulously, and meritoriously, devoted so much attention to this object, at the conclusion of his detail he observes, "The important enterprise is now offered to the speculation, and let us hope to the philanthropic views, of capitalists. Doubtless they will not be unmindful of the circumstance of their being entrusted with the providing for one of the chief wants of the inhabitants

of the capital of the world—a want that has hitherto been too incompletely satisfied, notwithstanding the constant solicitude of the magistrates of the city.

"Moreover, the inhabitants of Paris, in their relations with the company, should never forget that this great concern will tend to render the capital more salubrious, as well as afford security against the ravages of fire; and hence they will carefully abstain from abusing the advantages which circumstances may, perchance, place in their power. They ought to deem themselves happy, in having the opportunity of being supplied at their respective houses, not only without any trouble, but with *six times the quantity of water* at present provided for their wants, and at a much smaller expense than that which they now pay. Thus we may be enabled to modify our habitudes, by obviating the niggardly means heretofore employed to prevent a large use of this element of life, and source of domestic salubrity; and we may adopt those useful practices conducing to health and cleanliness, which have long prevailed among our neighbours in Great Britain. They, like ourselves, began by being tributaries to the carriers of water, who incommode us in our houses, as well as in the public streets, where we meet them at every step, annoying us both with their cries and the noise of their carriages, which also unpleasantly concur in augmenting the obstacles usually interfering with the public intercourse."*

During M. Mallet's sojourn in Great Britain, he was an attentive observer of various objects, besides the construction and management of water-works.—"Having fulfilled," says he, "the primary purpose of my engagement, with regard to the distribution of water at London,

* *Notice Historique, &c.* par C. F. Mallet, 1830.

I cannot abstain from succinctly presenting the results of some remarks made between London and Edinburgh. Our notice extended to many other subjects which relate to the occupation of an engineer: for instance, the paving of the towns, the roads that connect them, and the means employed to keep them in good condition, unceasingly excited our admiration, through a journey of 500 leagues. Our attention was equally directed to the construction of bridges, sea-ports, public edifices, sewers, railways—an object which more than ever occupies our neighbours, and is not far from producing among us a great change, in the various means of communication that have been used up to the present time."*

In a country so prolific in men alike eminent for perspicacity, scientific attainments, and practical ingenuity, it might reasonably be expected that, amongst the numerous improvements introduced into France, during the last forty years, some plan would have been realized, for affording a plentiful and cheap supply of water to its splendid and populous capital. London exhibited a striking contrast; and when the operations for supplying it, were not only well known, but readily applicable to any other great city, it may excite surprise that the enlightened people of Paris should not have undertaken and realized a similar plan.

The inhabitants of Paris chiefly obtain water for culinary and other purposes by the same inconvenient means that have been employed for ages. It is conveyed by conduits to different fountains, where each individual may procure it, or, he purchases it from persons who carry it in vessels from house to house for sale. In 1823, the number of people thus occupied, amounted to about

* *Notice Historique, &c.* par C. F. Mallet, 1830.

1400; their rate of charge is commonly about one penny for every six gallons; and they measure it with nearly as much nicety as is usual with other beverages. How strikingly different the accommodation at London, where the water not only flows into every house, but on the average costs only about one farthing the hogshead! The supply of Paris is not, however, wholly confined to the fountains and ordinary vendors. In its vicinity there is a filtering establishment, which employs 200 workmen,—130 of this number, with 109 horses, and 75 vehicles, are regularly engaged in conveying it to different parts of the city, where it is sold at the same price as unfiltered water. Each vehicle commonly makes two or three journeys in the course of a day, so as to distribute more than 50,000 gallons of it purified and perfectly limpid. It is procured from the middle of the Seine by means of an aqueduct, from which it is elevated by pumps into the buildings containing the filtering apparatus and reservoirs. This useful concern affords important accommodation to the numerous *restorateurs* of Paris, as well as to the residents of the *Palais Royale*, and its environs, for their various purposes.

Early in 1834, Messrs. Lees and Taylor presented to Louis Philip a plan for procuring water from the Seine, and conveying it into every street of Paris, as well as to the upper stories of every house, in the same manner as that practised at London. Accompanying it were sectional drawings for a subterraneous tunnel to take the water above the confluence of the Marne, and convey it to the centre of the hill of Ivry; thence to be raised by steam-power a perpendicular height of 150 feet into reservoirs, where, having deposited its sediment, it was afterwards to pass through filtering basins into an iron

main 36 inches diameter, to the Barriere d'Italie, for general distribution.

Paris abounds in fountains, of which about one hundred and twenty are inclosed; but more than sixty others are appropriated to the general use of the inhabitants, being also erected in convenient situations. In several of these public structures fancy and ingenuity have exerted their powers of diversifying exterior forms and ornaments to excite admiration;—the following are the most remarkable:—

The fountain called *The Innocents* is a very elegant edifice, affording a fine specimen of the French style of architecture. It is a quadrangular structure, and the base of each of the four sides has a square projecting stone, which supports a large leaden cistern of an antique form, with lion's feet. At the corners above these there are four lions of lead, through whose mouths the water flows into the several basins. In the middle of an arcade higher in the building is a pedestal, with a basin on its top, containing a *jet d'eau*. Each side of the edifice exhibits a portico composed of four fluted composite pillars, which are surrounded by a pediment. The spaces between the pilasters contains the figures of Naiads, and both above and below, different water-divinities are represented in basso-relievo. Small tablets of black marble, with the inscription, *Fontium Nymphis*, are placed on the upper part of the building, the whole of which has a spherical roof, covered with plates of copper.

The fountain of Popincourt is constructed in a style similar to that of the Innocents, and, being situate in a part of the city where the inhabitants are industrious, though very poor, it has appropriate symbols. The figures forming its ornaments are, Charity leading a little child,

Fountain of the Innocents at Paris

and at the same time hiding another in the folds of her robe, whilst she offers the cool delicious draught to allay the thirst of two others.

The figures and emblems which adorn several of the fountains are strikingly appropriate to their respective situations. That erected at the *Military Hospital* of Gros Caillou consists of eight pilasters, with a Doric entablature forming a square. Vases entwined by the Esculapian serpent are placed between the pilasters; and the principal front has a statue of Hygeia offering a refreshing and exhilarating draught to a soldier, apparently fatigued by the toils of a combat. The figure of the latter is generally admired for its skilful workmanship.

The fountain on the esplanade of the *Hospital of Invalids* is a large structure. It consists of a tier of three circular and concentric basins of large dimensions, but so placed one above another, that four lions convey a stream of water into the uppermost, whence it gently flows into the other basins below.

The design of the *fountain* of Dessaix is wholly different from any of the others. It has the form of a column, and France is represented as placing a crown of laurel on the head of the distinguished hero. The scenes of his victories and witnesses of his exploits—the rivers Po and Nile, are also displayed with their appropriate attributes. A basso-relievo surrounds it, containing two figures of Fame, inscribing, "Thebes, the Pyramids, Kehl, and Marengo." The front of the pedestal has the word Dessaix in golden letters, encircled with an oaken garland, and a splendid trophy adorns it behind. On the base are some appropriate inscriptions.

The fountain in the *Place du Chatelet* is formed of a large basin in which stands an Egyptian pillar, the lower part having the resemblance of a palm-tree, and the

chapiter being composed of its branches, with several heads emblematic of the winds. At different heights the words Lodi, Pyramides, Marengo, Ulm, and Dantzick are inscribed; and at its base are four statues, representing Vigilance, Fortitude, Prudence, and Strength. A gilded statue of Victory with extended arms, holding a wreath in each hand, stands on its summit, and cornucopias support a tablet at its base, on which is the figure of an eagle surrounded by a wreath.

Another superb fountain is that of *Grenelle*, which has the length of ninety feet by a height of thirty-six. This edifice is adorned with pilasters; and in niches the four seasons are placed, with appropriate bas-reliefs underneath them. On a pedestal in the centre a figure represents the city of Paris; and a little lower, on each side, a river god and a water nymph personify the Seine and the Marne.

The school of Medicine has a fountain which resembles a grotto. It is formed by four Doric pillars, and from the roof the water descends like rain into a semicircular basin.

The fountain of Leda is composed of two pilasters, that are surmounted by a pediment, with a basso-relievo representing Leda on the banks of the Eurotas, and Jupiter under the figure of a swan, with the water flowing from his beak.

The fountain of *St. Sulpice* is a square edifice, ornamented with emblematical representations of Peace, Agriculture, Commerce, and the Arts, in basso-relievo.

During the reign of Napoleon, the design for a new fountain was formed, and its execution was even begun, but it has not hitherto been completed. This is a subject of regret, because the scheme united novelty with magnificence; and its accomplishment would have exhibited some particu-

larly striking efforts in the arts employed for the purpose. The project consisted in forming and placing on an appropriate pedestal the figure of an elephant in bronze, seventy-two feet high, having a tower on his back, and the water was to flow from his trunk. Some conception may be formed of the stupendous dimensions of the animal figure, from one of the legs being adapted to contain the stairs leading to the tower on his back. The model for this ponderous structure was actually formed, and occupies a large shed contiguous to the place where it was intended to erect it, so that the public curiosity may be gratified by its exhibition. The situation chosen for placing it was near to the spot on which formerly stood that horrible state prison, and instrument of despotic caprice and cruelty—*the Bastile.*

CHAPTER XVI.

Scientific Knowledge, and Practical Skill essential for constructing Water-works. Statements and Suggestions of Professor Leslie. Effect of contraction in the Channel of a River, and circumstances relating to the motion of its Current. Velocity of the Rhone and the Thames. Resistance of Fluids similar to the friction of solid bodies. Greatest velocity of Rivers at the surface and middle of the Stream. Impulse of Water against a flat surface, and the piers of a Bridge. Comparative force of a Torrent upon blocks of Stone, Gravel, &c. Astonishing agency of Water under the guidance of human skill. Speculations concerning important objects to which it may be applied. Instruments for measuring the Velocity of Rivers. Crosley's Water-meters, and Brunton's for Liquids. Probable multiplication of Water-works, &c. Summary of facts relating to existing Establishments. Machinery employed in the operations at London, &c. Steam-engines, Valves, &c. Sources of Water at different places: Variations in the mode of supplying it, as well as quantities supplied. Reflections upon the advantages of modern Water-works.

It must be evident that scientific and practical knowledge of a peculiar kind is required, to construct works for supplying water to populous towns; and when it is procured from rivers, the velocity of their streams with other collateral circumstances, become the subjects of consideration and calculation. These have given rise to much speculation, as well as occasioned numerous experiments to be made by inquisitive and ingenious men; and the result of their investigations Professor Leslie has compressed into a compendious statement, which combines with it some of his own original ideas, and various interesting facts illustrative of the grand principles influencing several stupendous operations of nature. If

any of his notions be singular, no liberal mind will venture to designate them as the vagaries of a sanguine temperament, or a too fervid imagination, indulging in reveries upon impracticable schemes. Though machinery abounds in our own country, and the power of steam has been applied to an almost indefinite extent, yet hitherto science has not shed its light, nor art lent its aid, to many nations, so as to afford advantages similar to those enjoyed in Britain. Hence, it may be reasonable to presume that in those uncultivated regions, some versatile genius will probably render the suggestions of that eminent philosopher subservient to the comfort and prosperity of their inhabitants; for when Dr. Darwin wrote the following lines on the power of steam, he did not anticipate that in comparatively few years, his poetical vision would be nearly realized, by the velocity of motion effected on rivers and rail-roads:—

> "Soon shall thy arm, unconquered steam! afar
> Drag the slow barge, or drive the rapid car,
> Or on wide waving wings expanded bear
> The *flying chariot* through the fields of air."

"If the channel of any stream be suddenly contracted, the water will be forced to rise above its ordinary level. Suppose, for instance, that the flow was at the rate of a mile an hour; this might be considered as the effect of an incumbent column of four-tenths of an inch. But where the section of the current is reduced to one-half, the resulting celerity of two miles an hour would correspond to the pressure of an altitude of one inch and six-tenths. An accumulation of the water to the height of the difference, one inch and two-tenths would hence be occasioned by this obstruction. The piers of the old London Bridge were so massive as to reduce the breadth of the water-course from fourteen parts to three; and though the

velocity of the spring-tides be two miles an hour, yet this contraction occasioned an elevation equal to five feet at the principal arch, so as to increase the velocity at the fall to nine miles an hour, thus occasioning the shooting of the bridge to be attended with great hazard and danger.*

"The same principles which regulate the motion of water in pipes and along canals, are likewise applicable to the flow of rivers in their beds. Since the propelling power is proportionate to the elevation of the main source, the celerity acquired by those descending streams would become enormous, if their force were not gradually absorbed by the operation of some constant impediments. Suppose such a river as the Rhone to receive its principal waters at the altitude of 900 feet above the level of the sea, and that no system of obstruction had intervened in its course, it would have shot into the Bay of Marseilles, with the tremendous velocity of 240 feet in a second, or at the rate of 164 miles every hour. Even an inferior stream, such as the Thames, fed at the height of only 100 feet, would still, if not retarded by the attrition against its bottom and sides, have rushed into the sea, with a velocity of fifty-four and a half miles an hour.

"The resistance of fluids, like the friction of solids, thus enters largely into the economy of nature. As the latter is the great principle of stability and consolidation, so the former serves most essentially to restrain the accumulation of celerity, and to moderate all violent motions. A current presses forward with increasing rapidity, till the obstruction which it encounters becomes at last equal

* *Leslie's Elements of Natural Philosophy*, p. 393. In the work from which this and the following quotations are taken, the instances have algebraical formulæ accompanying them, adapted for the scientific reader.

to the inciting force; and having attained this limit, the water then continues to flow in an uniform stream. The maintaining power is proportional to the quantity of descent in a given space; but the impeding influence, depends on the surface of the bed of the river compared with its volume of water. This obstruction must at first augment very fast, being as the square of the celerity.*

"Experiments have proved that the greatest velocity in the flowing of a river is at its surface, and in the middle of the stream, from which it gradually diminishes towards the bottom and the sides, where, owing to the friction it becomes the slowest. Different circumstances, however, have the effect of either retarding or accelerating the motion of the current, thus requiring a modification of those calculations which proceed on the supposition that the river holds nearly a straight course. If it should wind considerably, the multiplied deflections which it suffers must still farther impede its motion. In every turn which it makes, part of its impulse will be spent against the concave side of the channel; the centrifugal effort will likewise raise the surface of the water in those sinuosities, and therefore augment the abrasion of the banks. Hence, no stream can be long confined to a rectilineal channel. If an accidental swell should once effect a breach, the sweep of the current must necessarily tend to enlarge the concavity by an accelerating progression; the opposite shore, from the accumulation of gravel and other deposits, gradually advancing into the channel. Rivers thus naturally form sinuosities; they seek to meander over the plains; and they would incessantly change their beds, if not restrained by sedulous attention, and skilful hydraulic operations. In such a country as

* *Leslie*, p. 422—3.

Italy, whose rich plains are swept by torrents from the Alps and Appenines, the superintendance of water-courses constitutes an important department of government.*

" If a flat surface be directly opposed to the action of a stream, as it shoots from the side of a vessel, it must evidently sustain a pressure just equal to that which projected the fluid, or the load of the incumbent column. In every case, therefore, the impulsion of any current against a perpendicular plane, may be estimated by the weight of a body of the fluid standing upon that surface, and having the altitude due to its velocity. This corresponds, in the case of a stream of water, very nearly to one pound avoirdupois, for every square foot of the obstacle, multiplied into the square of the velocity in feet each second.

" In practice, it may be sufficiently accurate, to reckon, for every square foot of opposing surface, the product of two pounds avoirdupois into the square of the celerity of the stream of water expressed in miles an hour. The pressure of a river against the piers of a bridge may be hence computed. The shock becomes augmented in a high ratio during floods; for not only is a greater extent of surface then opposed to the current, but the effort on every given space follows also the square of the increased velocity.†

" If the block should approach to a round shape, a torrent with the celerity of eight miles an hour would therefore be capable of rolling a stone of four feet diameter. But a stream gliding at the rate of two miles an hour would only be sufficient to carry along with it a pebble of three inches in diameter. With lower veloci-

* *Leslie*, p. 424—5.

† *Ibid.* p. 426.

ties the current will scarcely move gravel. If the particles of sand were supposed to have a diameter equal to the twenty-fourth part of an inch, it would require a flow of a quarter of a mile an hour to bear them along. A velocity of the tenth part of a mile in an hour would be sufficient to carry sandy particles of only the 123d part of an inch in diameter.*

"Water is the readiest and most powerful agent that can be directed by human skill. A mill-race for example, three feet broad, and two feet deep, and running at the rate of four miles an hour, would communicate an impulsion equal to the fall through 538 parts of a foot; whence the action thus created, during the space of a minute, is expressed by the product $3 \times 2 \times 352 \times 62\frac{1}{2} \times \cdot 538 = 70{,}966$, which being incessant, amounts to the ordinary labour of one hundred men. If this current had then fallen 26½ feet, its quantity of operation would have been augmented fifty times more. But such streams are easily collected and formed in numerous situations over the undulating face of the country.

"It will expand our conceptions, if we survey the great laboratory of Nature, and calculate the enormous extent of power, displayed in elevating the watery stores into the lofty regions of the atmosphere. Between the tropics, the annual fall of rain, and consequently the measure of evaporation which supplies it, amounts to about ten feet; and estimating this in other countries, as nearly proportional to the cosine of the latitude, the quantity of moisture exhaled in the course of a year, over the whole surface of the globe, would form a shell of five feet deep. The number of cubic feet of water turned into vapour, and dispersed through the mass of atmosphere every

* *Leslie*, p. 428.

minute, would hence be 5×10,424,000,000, or 52,120 millions. But this quantity is to be multiplied by 18,000, the mean height of the atmosphere in feet, and again by 62½, the weight in pounds avoirdupois of a cubic foot of water, the final measure of effect is therefore expressed by 58,635,000,000 millions, and equal to the labour of about 80,000,000 millions of men. Now the whole population of the globe being reckoned 800 millions, of which only the half is capable of labour; it follows, that the power exerted by Nature in the mere formation of clouds, exceeds, by *two hundred thousand times* the whole accumulated toil of mortals.

" A considerable portion of the power thus expended, might be directed to useful purposes, by intercepting the water again in its descent towards the ocean. Suppose one-sixth of all the exhalations to return to this great gulf, and that half of the falls in rivers and streams over the habitable earth, comprising the fifth part of the whole surface of the globe, are detained from an elevation of 600 feet; there would be drawn from those mighty stores a force *eleven times* greater than the aggregate of human labour.

" It may be satisfactory, however, to take a more definite illustration. The surface of this island is computed at 67,243 square miles, or 1,874,627,000,000 square feet. But reckoning the annual measure of rain 36 inches, of which the sixth part may flow towards the sea, and supposing one-half of this surplus, or three inches, to be intercepted at an elevation of 100 feet, it would require to multiply the former number 1562½, and divide the product by 525,949 the number of minutes in a year, to obtain the quantity of performance. The result is 4,423,760,000, equivalent to the action of 6,703 steam-engines, of what are called twenty horse power.

It may hence be estimated as not inferior to the ordinary labour of the whole of our male population. Such is the vast magazine of force, which a rigid economy might command.

" The power exerted by the moon and sun to heave the tides of the ocean, is only about the 80th part of the action of the atmosphere in producing the train of meteorological phenomena. Reckoning the swell at the equator to be four feet, this gives a mean elevation of two feet over the whole surface. Therefore, a body of water, two feet deep, is raised to the intermediate height of one foot twice in the lunar day, or 706 times in the course of the year. The relation of the force thus employed, to that of the general exhalation of water over sea and land, is one to eighty; and therefore still two thousand five hundred times greater than the aggregate labour of the human race.

" But the rise and fall of the tide, along our extended shores, would be sufficient to drive numerous mills. Suppose a basin were inclosed only a chain or sixty-six feet in width, and ten chains in length, and containing therefore an acre of salt water, this would give an impulse equal to the flow of 43,560 cubic feet in twelve hours and twenty-five minutes, or about 58½ feet every minute, with a fall of five feet.

" The performance of this tide-mill might hence be equal to that of twenty-five common labourers. But eight such basins could be included in each mile of coast; and therefore, estimating the circuit of the island at 1,750 miles, there might be formed no fewer than 14,000 mills, by drawing a sea-wall sixty-six feet from the shore. In this way, a saving of power might be effected, equal to the labour of 350,000 men. The expense of erecting such a dam, would probably defeat the object as a gene-

ral scheme of improvement; but there occur very many creeks and bights along our indented coast, which could be profitably inclosed as reservoirs for large tide-mills."*

Much ingenuity has been employed in devising contrivances, for ascertaining the rate with which flowing water moves in a channel, during a certain time; and among the most successful attempts of the kind is the following, as described by Professor Leslie:—" Since the pressure of a column of water occasions a corresponding flow, every current may be viewed as originating from the action of such a force, and can therefore be determined by the altitude of the incumbent fluid. Hence the construction of *Pitot's tube*,—a very convenient small instrument for measuring the velocity of any stream. It consists of a recurved tube of glass, of which the one branch is much taller than the other;—the short branch is bent at the top into a spreading funnel-shaped mouth, which receives the direct shock of the water, and communicating this impression, causes a proportional elevation above the common level. To prevent the irregular oscillation of the liquid in the syphon, it may be proper to have the bore much contracted in the whole of the under part of either branch. The object is further promoted by covering the funnel orifice, by a thin circular piece of brass with a very small hole in the centre. The pressure will be still propagated as before, but with more steady effect. The divisions on the scale are reckoned upwards from the surface of the stream. The rise corresponding to the rate of a mile an hour would be four-tenths of an inch;—the scale would hence be marked, 1, 2, 3, 4, 5, 6, 7, 8, 9, &c. miles, at the respective heights of ·4,—1·6,—3·6,—6·4,—10·0,—14·5,—19·7,—25·8,—32·7, &c. inches. Few

* *Leslie*, p. 429—32.

rivers, therefore, would require the glass tube to rise six feet above the surface of the water. The instrument may be composed of a long narrow tube of brass, or tin, cemented to a wide cylinder of glass, carrying the divisions."*

Another instrument applied to the same purpose is similar to that used by mariners at sea, to determine the rate of a ship's sailing with a favourable wind. It consists of a nicely graduated brass wheel, with very fine teeth, that fit the grooves of an endless screw, formed on a steel spindle adapted to work horizontally by a brass fly fastened to its end. The wheel has a vertical motion, and its axis is fixed in a moveable frame, so that by means of a silk line and a spring, it can either be instantly brought into contact with the screw, or put out of its influence, at the pleasure of the operator. To render the instrument steady when exposed to the action of a current, a broad oblong brass plate is also attached in a direct line with the spindle, and opposite to the centre of the fly. The divisions on the wheel are marked from one to two hundred and fifty. Its use requires great care and attention; and when employed to indicate the rate at which a stream flows, it is affixed to the end of a rod about six feet long by means of an elastic socket. A certain distance,—for instance 100 feet,—being accurately measured by the side of a reservoir, or pond where the water is perfectly still, the instrument with its fly foremost is plunged several inches below the surface, and by pulling the line the wheel is then brought into contact with the screw, when the machine is moved from one end of the measured space to the other. The number of revolutions registered by the wheel forms a standard for judging of the rate of motion at which a current flows;

* *Elem. Nat. Phil.* p. 390.

but to determine the latter point, the instrument is fixed in the centre of the stream, and the number of revolutions produced by its flow in a given time, being compared with the number produced in moving it through a certain space, enables the operator to form a conclusion with regard to the velocity of a river. It will be obvious that this contrivance is applicable to any depth; but to form a tolerably correct decision, it is necessary to make several experiments, and take the average of the whole.

The Water Companies of London have long been desirous of finding out and adopting some plan, by which the quantity of water consumed in every house should be exactly ascertained and registered, so as to enable them to make an equitable charge to each, in proportion to the supply. Exclusive of the justice and satisfaction attendant upon such a practice, other advantages would also be the result, particularly the saving of water from any unnecessary or wilful waste. For if the large conduit pipes were continually conveying it from the reservoirs without any restraint, the neglect to close the outlets, and profusion in its use, would probably occasion the expenditure to be so excessive, that it would be impossible to regulate the supply, or in some instances to prevent the absolute want of water, altogether. To obviate such inconveniences, is the principal reason for pursuing the system of turning on the water for two or three hours, on two or three days in a week, in order to fill the cisterns or baths placed in every house, so as to furnish an adequate supply during the intervals of its not flowing from the conduit pipes.

It may not be improper to remark that advantageous as this method must be deemed, it entails an inconvenient expense upon the poorer class of society, inasmuch as they have to provide butts or cisterns, with necessary pipes and

other fittings, as well as to keep them in repair, besides in many cases not having room to place vessels sufficiently large for their wants and purposes. On the contrary the Water Companies are also liable to fraud from designing persons, who have it in their power, by filling other vessels whilst the water is flowing into their cisterns, to take three or four times the quantity intended for them to receive. Besides such establishments as breweries, distilleries, and various manufactories, which require large supplies, as well as at uncertain periods, cannot, on this system, be accommodated without having cisterns or reservoirs, of great magnitude. Hence, by an arrangement sometimes made between concerns of this kind and the Water Companies, the latter are compelled to keep the water constantly flowing from the pipes, so that an indefinite quantity may be taken, or allowed to escape wastefully.

The above considerations will show the importance of having a *measurer*, which shall correctly indicate the quantity of water received by each establishment, so that the sum charged for it may be exactly in proportion to the consumption, in the same manner as payment is made for *gas* by the *meter*, which is now very generally adopted throughout the United Kingdom. In some instances the Water Companies have contracted with large establishments to supply them, at a certain rate, through an aperture or sluice of fixed dimensions, constantly running, and having a certain pressure; but there are very few situations that admit of such requisites.

Several attempts have been made to furnish a *Water Meter*, applicable to all situations and circumstances, as well as at a moderate cost. The most ingenious and efficient of these contrivances seem to be the *Liquid Meters* invented by Mr. Samuel Crosley, and another by

Mr. Brunton, for which each has obtained a patent; and the following is a brief description of their principle and mode of acting.

Mr. Crosley has devised two modes of measuring liquids,—one of which consists in employing a hollow drum, or wheel, divided into compartments similar to that of a *Gas Meter*,* with such modifications as are necessary to ensure that each chamber in succession shall be accurately filled with water as the wheel revolves; and as its axis is connected with a train of wheel-work adapted to register the quantity correctly, the amount may be entered in a book at the end of any period that shall be requisite. The other contrivance effects the same object by means of a trough, open at both ends, and having a partition at its middle to divide it into two equal portions. The trough is mounted and suspended on an axis in the centre under the partition, in the same manner as a weighing beam; and below this axis is a stop or rest at each end, upon which the trough falls alternately, as each portion of it is filled with water. The mode of admitting the water is through an aperture, placed exactly over the centre of the trough, so that when one of its ends falls down to discharge its contents, the other turns up, assuming the form of a hopper, and when full, its weight occasions it to fall, and thus at the same time brings the opposite end under the orifice to be again filled in a similar manner. The two rests serve to regulate the quantity

* The resemblance of this machine to the Gas-meter will be obvious, though with this difference in their manner of operating. When a Gas-meter is in use, it has *the upper part* of the hollow wheel filled with gas, but the part below it is occupied by water, in order to form a boundary. On the contrary the Liquid-meter has *the lower part* of the wheel occupied by the liquid, whilst the remaining space above is filled with compressed air.

Fig 1	*Section of a Rotatory Meter across the Axis*	
Fig 2	*Section of the same lengthways of the Axis*	
A.B.C.D.E.	*Our Vessel A.B The same letters apply to both Figures*	
F.G.H.	*Measuring wheel with three compartments*	
l	*Inlet to compartment F.*	*m its outlet*
i	*Inlet to*	*G. k its outlet.*
n	*Inlet to*	*H o. its outlet.*
p.q.Fig 2	*Pipe to admit the liquid.*	
r s	*Axis of the measuring wheel*	
t v	*Wheel Work and index*	
w.y.z	*Trough in which the wheel moves*	
E	*Discharging pipe and cock*	

Fig 1.

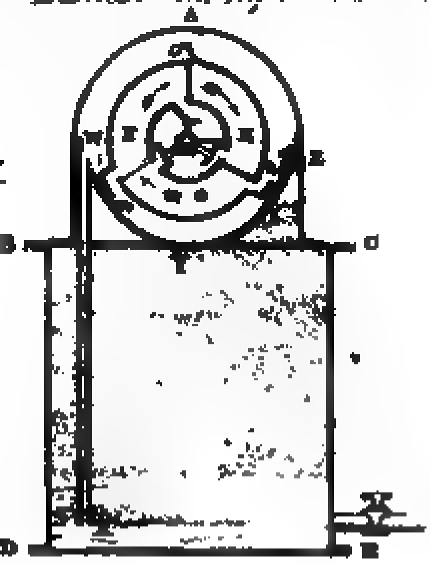


Fig 2

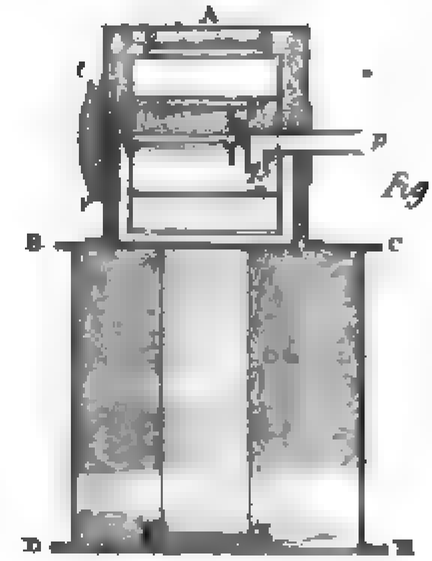


Fig 3

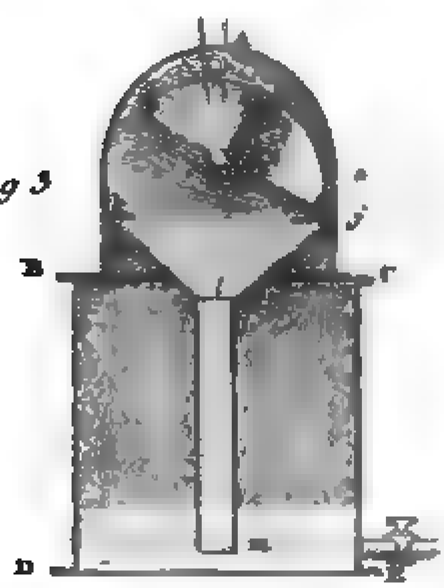


Fig 4.

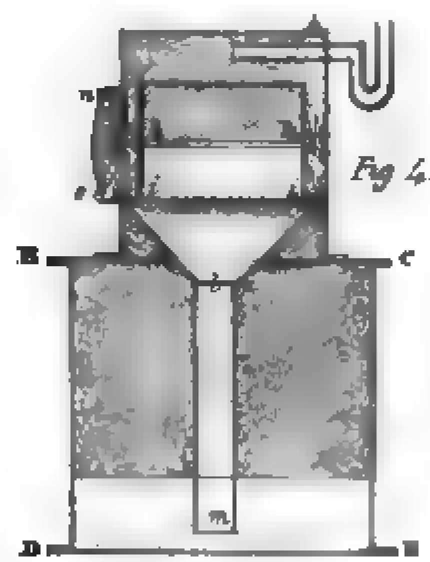


Fig 3	*Section of a Reciprocating Meter across the Axis*
Fig 4	*Section of the same lengthways of the Axis*
A.B.C.D.E.	*Our vessel*
f g h i	*Measuring trough*
h h	*Its Axis, and j k the rests when it falls down*
J	*One end of the trough down, while the other f g h is filling by the pipe A*
l m	*Funnel to receive the water from the trough when it falls*
n o	*Glass Cover for the index of the wheel work, connected with the Axis h h.*
E	*Discharging pipe and cock*

CROSLEY'S PATENT LIQUID METERS.

C. F. Cheffins lith. 3 Wellington St Strand

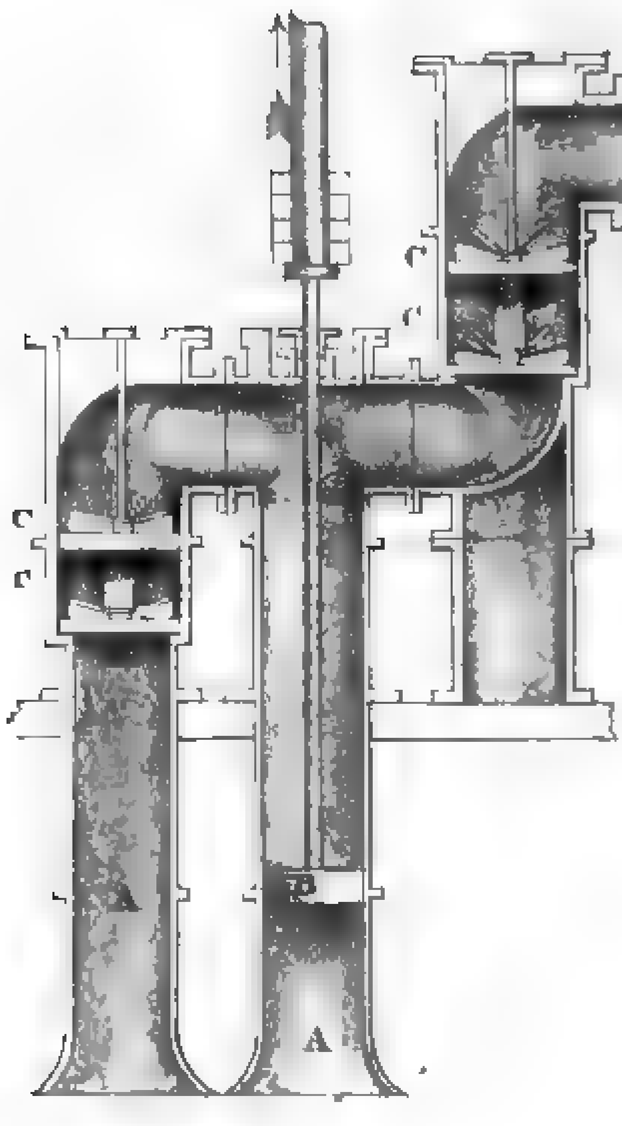
of water required to fill each portion of the trough; and the successive motion of its axis being produced by their alternate rising and falling, the train of wheel-work connected with the machine for the purpose, registers the quantity, as in the former contrivance.*

In both these machines, the inventor employs the following ingenious device for adapting them to any degree of pressure, or head of water, under which they may be required to operate; and without this, or some other equally efficient provision, their use would be confined to the very few situations of a running stream, where there is scarcely any head of water. In order to effect this object, the measuring apparatus is enclosed in an air-tight vessel, of suitable form, strength, and dimensions, and it is likewise placed near to the upper part of the vessel, so as to leave the necessary space beneath, for receiving the water after its measurement. The depth or space required for this purpose will depend on the pressure or head of water for which the apparatus is to be adapted. The principle of this arrangement consists in counterpoising the head, or column of water, by the air contained in the air-tight vessel, so that when a sufficient quantity has been admitted, it will then occupy the lower part of the vessel, and compress the air in the upper part, until its force shall be equal to the pressure of the head of water above it, and will thus prevent the entrance of any more, except when the pressure of the air is diminished, by a quantity of water being drawn from the bottom of the vessel. Hence, a pipe leading from the measured water may branch off to various parts of a house, and furnish a sup-

* This machine has been successfully tried, at the Royal Observatory, Greenwich, and many other establishments, as an improvement in the *Rain Guage:* and it may be seen at Messrs. Watkins and Co., Charing Cross.

SECTION

of the Lifting & Forcing Pump employed at Water Works



A. A. . . Cylinders
B . . . Piston.
C. C. C. C. Valves.
D . Discharging Pipe.

G. F. [illegible] Lith. 7 Wellington St. Strand

than water, inasmuch as their value may be materially affected by those circumstances. Hence, probably his contrivance might be applicable to the purposes of revenue at distilleries, and in some other cases; but for water, those devised by Mr. Crosley, are evidently preferable, from being simple in their construction, effective in their operation, and requiring little attention when once adapted to their place. Partial and limited as the use of such measuring machines may have hitherto been, it is presumed, that eventually they will be extensively employed by the Water Companies, from their affording a correct standard for payment, besides occupying a comparatively small space, and being made at a moderate expense.

If the object of many of the contrivances described in the preceding pages be the same, yet some of the principal are so diversified either in construction or operation, that perhaps a summary view of their peculiarities may not be irrelevant. The abundant supply of water to Rome, Constantinople, and Edinburgh, being procured from high situations, flows to the respective cities by its own natural gravity. London, Liverpool, and Paris, are partially supplied by similar means; but as a considerable portion of the water, for the use of these and other places, is obtained from rivers or springs below their level, steam-engines with a variety of apparatus are required, for elevating and distributing it amongst their residents.

The steam-engines employed at water-works are generally constructed with both *lifting* and *forcing* pumps—the former being adapted to raise the water out of the wells that receive it from the rivers, and the latter to impel it either to lofty reservoirs, or to such domestic cisterns, as may be situate above the level of the original source. When the mains are of great length, and also laid exactly horizontal, the use of the forcing-pump be-

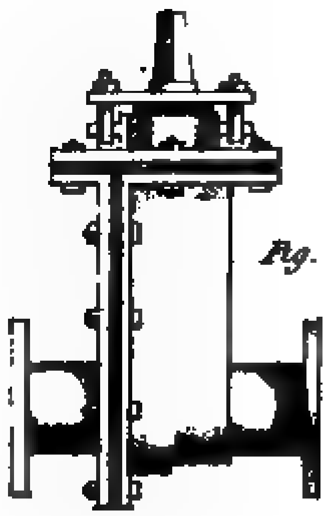
comes essential for communicating an impulse to the current, which may be retarded in its course, by friction against the interior surface of the pipes. But the following instances will place the utility and importance of these powerful machines in a striking point of view.

The reservoirs belonging to the West Middlesex water-works are constructed upon very elevated ground, —that at Kensington being 122 feet, and the other at Barrow Hill, 188 feet higher than the level of the Thames; nevertheless, the whole of the water for their purposes is conveyed to them from the river, by a train of iron pipes nearly two feet in diameter, and several miles in length, gradually ascending to their respective summits. A similar method is likewise adopted for conveying water from the Thames to the reservoirs of the Chelsea,—the Grand Junction, and several other water-works which supply London and its vicinity.

Wherever the trains of pipes for conveying water from its source have a considerable ascent, as well as great length and large dimensions, if the vast quantity which they are adapted to contain were allowed to exercise all the force of its gravity to the highest elevation, without any interruption, from one extremity to the other, its pressure would tend to produce such a re-action upon the power of the steam-engine, as would materially diminish its effect. Hence, to obviate this inconvenience, at different heights on the mains are placed *self-acting valves* which regulate its retroaction. These valves are made with iron, and consist of a strong frame, having a door or lid nicely fitted to it with hinges, so as to open when the water ascends, and to shut by its backward pressure.

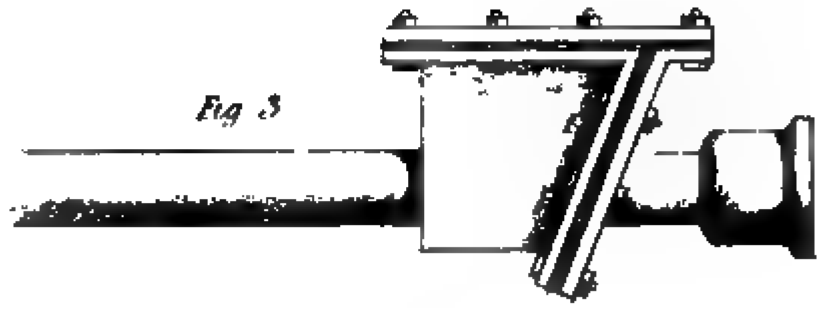
In London, and many other places, each house is generally provided with one or more cisterns of adequate

Fig. 1



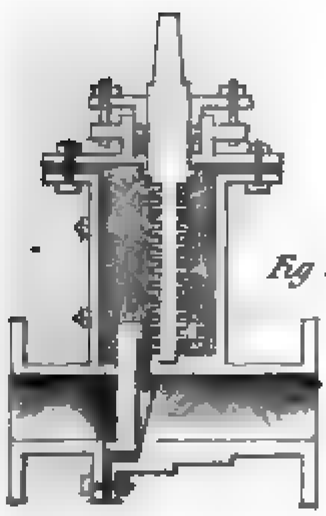
Screw Valve

Fig 3



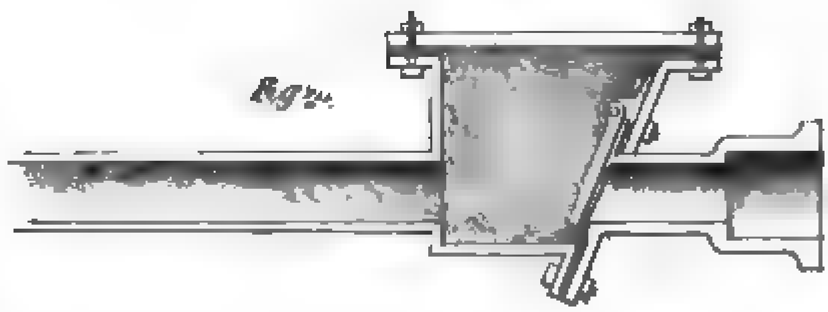
Self acting Valve

Fig 2

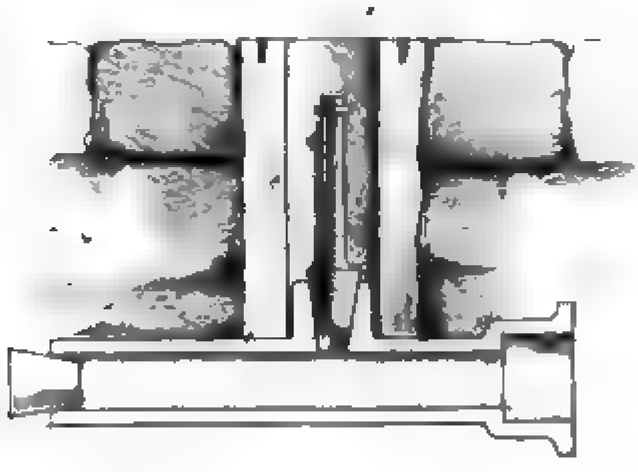


Section

Fig 2a



Section



Section of a Fire Plug

G. E. Madeley, Lith. 3 Wellington St Strand

dimensions, and the water flows into them only at certain regular periods, by the opening of valves, fixed for that purpose at convenient places on the principal mains, which convey the water along every street. This kind of machine is commonly constructed of an iron frame, with a smooth iron plate accurately fitted to slide up and down in a groove, and attached to a screw, which raises or lowers it, so as to permit the water to fill the cisterns, or stop the current when they are properly supplied. It is usually called a screw or slide valve. For the purpose, also, of regulating the flowing of the water to the cisterns, each small pipe, employed for conveying it from the mains, has a brass cock affixed to its extremity. The valve of the cock has a square projecting pin, to which is attached a copper rod with a globe or ball adapted to rise and fall, so that its ascent, by the filling of the cistern, closes the opening when it is quite full.

Though the natural tendency of water be to flow down a declivity, yet the levels of different parts of many towns are very irregular, and therefore require the pipes to be placed either in ascending or descending directions, according to circumstances, so as to adapt them to different situations. The course of the water being thus rendered undulating, its current sometimes encounters interruptions by the air disengaged from it collecting in the pipes, and this particularly occurs when they are not kept completely filled. Hence, contrivances are necessary for its discharge; and one of the methods employed is that of opening the orifices,—called plug-pipes,—which afford the supply of water on occasions of fires. The same object is effected at Edinburgh by means of circular cast-iron boxes, about four feet high, and one foot and a half in diameter, which, being affixed at the summit of each declivity, are opened by the surveyor of the works,

every two or three days, in order to allow the air to escape without any loss of water.

The sources whence different places derive their supply are so various as to be deserving of notice. At Liverpool it is obtained from abundant springs in its vicinity; but at Manchester it is collected from the lands surrounding the reservoirs, which are constructed to receive and preserve it for distribution; whilst an exuberance is procured for Greenock from the small streams, which the dews and rains produce in the neighbouring mountains. London and Glasgow are chiefly supplied by the grand rivers on the banks of which they have their respective sites.

The water furnished to Edinburgh, and in part to Liverpool, being conveyed directly from springs, is naturally pure and limpid; and the abundance flowing to the former enables the inhabitants to have the use of it without limit or restraint. But according to an estimate made of the quantity that each inhabitant of the respective places daily receives, it amounts, on the average, at London, to about ten gallons,—at Glasgow, twelve,—at Edinburgh, seven and a half,—at Manchester, five and a half,—and at Liverpool about three and a half gallons. Glasgow, Greenock, and that part of London in the Chelsea Company's district, are supplied with filtered water; and the extensive and complete success of the operation at these establishments, will probably lead to its adoption at every other, where the water is obtained from rivers. The practice indeed appears indispensable, in order to obviate the objections of the fastidious; and though it would occasion some addition to the charge for it, the cost would be a trivial consideration compared with the advantage of a constant supply of pellucid water. The prices for it vary in different places, and even in the

same place, according to circumstances, but in every one they are moderate for the advantages afforded.

At London, Liverpool, Edinburgh, and several other considerable places, the principal establishments have provided the means of supplying water to all the different stories of the highest houses, within the limits of their distribution; exclusive of an abundant quantity for every useful purpose, extinguishing fires, &c.; hence their operations are the most complete and effective of their kind. As works of this description evidently afford the means of easily obtaining a plentiful supply for any important object, the expectation may, perhaps, be confidently indulged, that wherever they are constructed, the inhabitants will be stimulated to construct *capacious and convenient baths* for their general accommodation. The utility of such contrivances would be obvious, in their tendency to promote the healthful and cleanly practice of bathing. Hence, the habit might become common both among the refined and less cultivated residents of Britain, so that even in this particular, we might challenge a comparison with the people of any other country, on the surface of our habitable globe.

It has been estimated that the iron pipes of different dimensions, laid in various directions, to supply London and its vicinity, measure from one to two thousand miles. Probably all towns having a large population, will eventually adopt plans similar to those for supplying the metropolis, and propel water from comparatively low situations into lofty reservoirs, from which it can be most conveniently, readily, and cheaply conveyed to the inhabitants, for domestic and other purposes. If great profit do not accrue to the persons who may first engage to furnish the capital for accomplishing such important works, it may be fairly presumed that the results will

ultimately prove beneficial, especially in places where they shall originate in the public exigences, rather than in the spirit of avaricious speculation.

Among the benefits which large towns may derive from establishing water-works, must be enumerated, their furnishing ample means for cleansing all subterraneous drains, and therefore removing the annoyances to health and comfort which would otherwise result from them. The stupendous sewers of Rome have often been applauded for their utility; and those of London are more extensive, though less in magnitude. As early as the time of Henry VIII., the care and management of these structures was particularly provided for, by Act of Parliament. Probably such was the case long before; but subsequent Acts have confided their superintendance to a considerable number of commissioners, who are invested with powers to preserve them in good condition, by constructing and repairing any that may be necessary, and likewise to compel the inhabitants to pay the expense that may be incurred. Some of the sewers have a perpendicular diameter of five or six feet, so that the currents produced by rain, and the abundance of water which constantly flows into them, from the great supply of the different water-works, effectually cleanses them; yet as these operations are not commonly exposed to public view, their advantages are not duly appreciated.

This compendious and imperfect survey will, perhaps, exhibit the superiority of modern science and art, in a comparison with those of the ancients. The Roman aqueducts,—the machinery of Egypt,—the Souterazi of Constantinople, and some other contrivances of former times, strongly excite our curiosity, and claim admiration; but how obviously inferior are they, in many respects to the ingenious inventions of a later period for similar pur-

poses. Chemistry having disclosed by what means the potent agency of steam may be employed and regulated, for almost indefinitely augmenting mechanical force, the skilful application of this great elastic power, has facilitated the execution of plans for affording an exuberant supply of water to any city, whatever may be its extent, —the loftiness of its buildings, or the number of its population. By the aid of steam-engines every difficulty of situation is readily overcome; and thus the genius and skill, of a recent era, have in a great degree superseded the labour of ages,—tended to obviate the expenditure of millions, besides rendering the devices of our progenitors useless, for the purposes which originally occasioned their construction. Hence, the most important, useful, and admirable objects may be accomplished, without having recourse to the painful and degrading drudgery of slaves, as was heretofore the case in some countries. The toil of domestics is also diminished, by the waters of distant rivers, and fertile springs, being now readily and constantly conveyed into the interior parts of our dwellings,—even to our sleeping-rooms and fire-sides. Thus have science and art largely contributed to the exigences, comforts, conveniences and enjoyments of social life, though we may not have structures resembling either in form, or magnitude, the superb Aqueducts, *Thermæ* or *Naumachiæ*, of the Romans.

CHAPTER XVII.

Agency of Nature in accomplishing apparently simple but great purposes. Remarkable effects of Evaporation. Experiments of Saussure; Calculations of Bishop Watson and Dr. Halley. Estimate of Rain in different latitudes by M. Humbolt and Dr. John Dalton. Abundance of Water suspended in the atmosphere, when the sky appears very clear. Velocity and effects of Winds. Constantly varying modifications of the Earth's surface, but its equilibrium preserved. Difference in the properties of Water; causes of its being hard or soft. Rain-water. Rivers. Stagnant Water. Men prefer it transparent, but some Animals occasionally render it turbid before they drink. Practice in Italy of mixing Salt with it. Qualities of Water in its natural state. Statements of Dr. Henry and Dr. Turner. Transparent Water desirable for beverage, &c; mode of obtaining it in Turkey. Springs, natural filters. Importance of Filtration of Water procured from rivers.

Several very striking facts relating to the subject of water, exhibit the incessant agency of nature for accomplishing momentous purposes; whilst others favourably display the varied energies of human intellect, in forming contrivances to remove obstacles, and overcome difficulties, which, in peculiar cases, apparently interfere with the wants and comforts of mankind. The large quantities of water collected to supply Constantinople and Greenock corroborate this assertion; and may authorize a few remarks concerning the origin of those numerous rills, which generally fill their capacious reservoirs. Although it may escape the notice of an unreflecting observer, the source whence they may be traced is the evaporation constantly operating over the surface of our terraqueous globe. The atmospheric air seems to be

a principal agent in producing this effect, inasmuch as it contains such a portion of heat as not only converts the water into vapour, but also occasions the union of air with water, when both come into contact. A familiar instance illustrative of this fact frequently occurs after casual showers in windy weather; for the public streets and roads rapidly become dry, even in cloudy days, when the direct rays of the sun seems to have no particular influence.

Different philosophers have made a number of experiments to ascertain the capacity of atmospheric air for holding water in a state of solution. The results of those by M. Saussure led him to conclude that eleven grains of water would unite with a cubic foot of air; but in general the quantity varied from five to ten grains. Bishop Watson estimated the produce of evaporation from an acre of ground at more than 1600 gallons, during the space of twelve hours in a hot summer's day; besides his experiments for the purpose were made whilst the earth was apparently very dry, and when no rain had fallen for a considerable time.

Though the circumstances already mentioned show that abundance of moisture is constantly present in the atmosphere, yet there are others that demonstrate the wonderful extent of natural exhalation. Three-fourths of the surface of our habitable globe being occupied by water, and covering an area of about 145 millions of English square miles, the quantity evaporated from the Mediterranean Sea alone will afford a criterion for a reasonable conclusion on the subject. Some experiments made by Dr. Halley countenanced his inference, that one-tenth of an inch of the surface of that sea was daily raised in the form of vapour. Hence, he observes, that "Every ten square inches of the surface of the water

yields in vapour *per diem*, a cube inch of water; and each square foot, half a wine pint; every space of four feet square, a gallon; a mile square, 6914 tons; a square degree,—suppose of sixty-nine English miles,—will evaporate thirty-three millions of tons: and if the Mediterranean be estimated at forty degrees long and four broad, allowances being made for the places where it is broader by those where it is narrower, there will be 160 degrees of sea; and consequently the whole Mediterranean must lose in vapour, in a summer's day, at least 5280 millions of tons. And this quantity of vapour, though very great, is as little as can be concluded from the experiment produced: and yet there remains another cause, which cannot be reduced to the rule,—namely, the winds,—whereby the surface of the water is licked up, somewhat faster than it exhales by the heat of the sun, as it is well known to those that have considered those drying winds which sometimes blow.

"The Mediterranean receives these considerable rivers: the *Iberus*, the *Rhone*, the *Tiber*, the *Po*, the *Danube*, the *Niester*, the *Borysthenes*, the *Tauris*, and the *Nile*, all the rest being of no great note, and their quantity of water inconsiderable. We will suppose each of these nine rivers to bring down ten times as much water as the river Thames,—not that any of them is so great in reality,—but to comprehend with them all the small rivulets that fall into the sea, which otherwise I know not how to allow for.

"To calculate the water of the Thames, I assume that at Kingston Bridge, where the flood never reaches, and the water always runs down, the breadth of the channel is a hundred yards, and its depth three, it being reduced to an equality, in both which suppositions I am sure I take to the utmost. Hence, the profile of the water in this place

is 300 square yards: this multiplied by forty-eight miles, —which I allow the water to run in twenty-four hours, at two miles in an hour,—or 84,480 yards, gives 25,344,000 cubic yards of water to be evacuated every day,—that is 20,300,000 tons *per diem;* and I doubt not but in the excess of any measure of the channel of the river, I have made more than sufficient allowance for the waters of the Brent, the Wandel, the Lea, and Darwent, which are all worth notice, that fall into the Thames below Kingston.

"Now if each of the aforesaid nine rivers yield ten times as much water as the Thames doth, it will follow that each of them yields but 203 millions of tons *per diem*, and the whole nine but 1827 millions of tons in a day, which is but little more than one-third of what is proved to be raised in vapours out of the Mediterranean, in twelve hours' time."

Other facts having a reference to this subject are likewise deserving of attention. As it became an object of inquiry, whether the rain and snow, usually falling in the course of a year, would produce a quantity of water equal to that, which the rivers, supplied by springs, annually discharge into the ocean, various calculations were made for the purpose, and they showed the inadequacy of such a source. But the experiments of Dr. Halley upon the effects of evaporation, demonstrated it to be the efficient cause of the abundant supply of water; and the immense volumes of vapour, constantly exhaling from the surface of the terraqueous globe, probably afforded even a greater quantity than seemed to be requisite, to compensate for any deficiency arising from the other. Another cause that was not known in Dr. Halley's time may also be stated; and although apparently trivial, it certainly contributes a portion towards the mighty mass. The artificial flames employed to illuminate our private

dwellings, or to dispel the darkness of the midnight hours in the public streets, constantly produce water, by combining the elements that go to its formation. This is one of the discoveries of modern chemistry.

Natural evaporation has excited a high degree of curiosity amongst philosophical observers, and their inquiries and speculations, have been equally interesting and instructive. Though the moisture contained in the atmosphere forms the clouds, yet the rarefaction of the air renders it incapable of sustaining them at an average height of more than about a mile—their elevation varying from 4500 to 7500 feet: — and even as usually saturated with vapour through this large space, it has been calculated that the whole quantity of water held in solution, would not form a mass exceeding five inches in depth. Hence, it will be evident, that as the quantity of water annually falling from rain and dew, probably amounts from thirty-five to nearly forty inches, in order to produce this effect, the frequent renewal, or constant accession, of atmospheric moisture, becomes essential during the course of the year.

The fact has likewise been ascertained, that a greater portion of rain descends whilst the sun is below, than when it is above, the horizon; and though the whole quantity, annually falling upon the soils ordinarily composing the surface of the earth, may amount to nearly forty inches, yet about thirty inches are exhaled by evaporation. Its proportion, however, varies according to the temperature of different climates, and the average is greatest at the equator, but from that point the quantity gradually decreases in a direction towards the poles.

Another remarkable circumstance is the number of rainy days, which occur in different latitudes. Notwithstanding the depth of rain be annually greatest within the

torrid zone, nevertheless, it appears that the number of days, when it falls, is comparatively small, and that it progressively increases in advancing from the equator to high latitudes. But to this statement there are exceptions, for rain seldom or ever falls in several tracts of the torrid zone;—such for instance as Sahara desert in Africa,—a large part of the shore of Peru, and the low coasts of the Caraccas. Even in some high latitudes, so trivial is the quantity of atmospheric moisture, that it scarcely ever rains.

M. Humbolt has given an estimate as an approximation to accuracy, of the probable quantity of rain which annually falls in different parallels, calculating its depth in English inches. According to this,—

In Lat. 0° it amounts to	96 inches.
19°	80
45°	29
60°	17

From various observations, the following results have also been deduced, with regard to the average quantity of rain annually falling, at the several places enumerated:—

At Grenada	in 12° N. Lat. it was	126 inches.
Cape Français	19·46	120
Calcutta	22·23	81
Rome	41·54	39
England	53°	32
Petersburgh	59·16	16

In England, however, it varied at different places, and though the result of six years' observation, at Oxford, produced an average of less than twenty-two inches, yet at Tottenham, the quantity in 1821, exceeded thirty-three inches. Mountains and elevated places seem also to have considerable influence; for it has been observed that at Kendal and Keswick, from sixty-seven to sixty-nine inches of rain annually fall, but only about twenty-

four inches descend in the level country, and near the sea-coast. Similar effects have likewise been remarked as occurring at Geneva and Paris;—the former having an annual fall of rain amounting to forty inches; whilst at the latter, though 300 miles nearer to the sea, it does not average quite twenty inches. Numerous observations induced Dr. John Dalton, of Manchester, to infer that, in England, rain annually deposits thirty-one inches of water, and dew, five inches. Many other instances of the diversified operations of nature might be adduced; but the few which have been given, will afford an ample illustration of their object.

All solutions being facilitated in proportion to the degree of heat concerned, in effecting them; hence, evaporation is increased in the same ratio, as the temperature of the air becomes augmented. This is rendered obvious by the exhalations of our climate, from the vernal to the autumnal equinox, which are found to be about four times the quantity of that, produced during the period which elapses between the autumnal and the vernal. The vapour generally occupies the lower part of the atmosphere, but it sometimes ascends very high, forming those light and beautiful clouds often observable in the driest seasons, when the sky is very clear; thus affording evidence of the abundance of water constantly existing in the air. Indeed, evaporation may be deemed the primary cause of dews, mists, rain, &c.; and although the ocean be salt and rather bitter, the water exhaled is free from any admixture of such qualities.

Invisible, as may be the minute particles of water, when exhaling from the ocean, or the land, yet ascending by their levity, and aggregating, they form the clouds which afterwards descend in rain. Others also being attracted by the earth are deposited upon its bosom, and

either penetrate its pores and fissures to supply the springs, or gradually accumulating and combining, flow in little streams down to the valleys, where, by their multitudinous union, they become great rivers, constantly rushing to disembogue their contents into the ocean, to be again returned to the atmosphere by exhalation. Hence, the same fluid incessantly circulates, either to satisfy the wants, and contribute to the enjoyments of animated beings; or to afford its aid in the processes of vegetation by furnishing nutriment to the forests and the fields, with their exuberant variety of foliage, fruits, and flowers, investing "our diurnal sphere" with grateful verdure, or enchanting beauty.

How truly admirable, therefore, is the provision for widely and universally diffusing this useful element, and distributing it over the surface of lands far distant from the ocean! The air being agitated by various causes produces those currents, usually denominated *winds*, which, in many cases sweep over a vast space, with a velocity of more than sixty miles in a minute, and thus convey nutritious moisture to the trees, and plants, and flowers of every soil, and the most arid regions. At the same time they also minister to the supply of innumerable springs and rivulets, whose united effects compose the immense mass of water continually filling the channels of magnificent rivers, and forming mighty torrents, that flow back to that grand source whence they were taken in the minutest particles! Nature, ever bounteous and beneficent, thus regularly and perennially performs her "mysterious round" of operations, to subserve the purposes of animal and vegetable existence; but whatever changes affect the relative position of the minute parts of matter constituting our habitable globe, and constantly varying as may be the modifications of its general surface, yet from the

reciprocal influence of causes, and effects, the mass always remains the same so as preserve its equilibrium.

Many domestic as well as various other operations, indispensably require, not only salubrious, but *soft* water for their purposes. Transparent, however, as spring-water may generally be, yet by passing through certain strata, it often becomes combined with sulphate of lime, which renders it *hard*, and consequently unfit for washing and different other uses. Occasionally too the muriates, sulphates, or carbonates of soda, magnesia, or lime, and also the oxide of iron, &c., are dissolved in it, which produce a brackish, and an unpleasant taste. Thus a diversity of circumstances affect many springs that contribute their aid to form rivers, which, nevertheless, furnish very pure and soft water; but its qualities undergo an alteration, by rapid motion, and exposure to the action of the sun and air. These occasion the decomposition of salts which they may contain;—the carbonic acid likewise escapes, a precipitation of the earthy particles mixed with it takes place, and thus the water becomes purified and is rendered soft. Besides rain being commonly softer than the water derived from other sources, the great quantity, which falls and flows into the channels of rivers, and passes over a considerable surface, materially improves the qualities of the whole mass, so as to render it preferable to that immediately obtained from springs for a great number of economical purposes.

When water is confined, without having any motion, either by a current passing through it, or otherwise, it generally acquires an unpleasant odour and taste, particularly in hot weather. In this state it abounds with animalculæ, generated during the decomposition of animal and vegetable matter, which occasion its opaque, coloured, and repulsive appearance; consequently, the

putrescence attending the gradual decay of the animal and vegetable substances render it offensive to the senses, as well as objectionable and unwholesome for beverage and other domestic uses. Operations of this kind, however, constitute a necessary part of the grand system of the universe,—silently but powerfully concurring to maintain and regulate its harmony. The decay and dissolution of some bodies seem to be absolutely essential to the formation and existence of others, having the same ends, and in their turn, being liable to similar mutations. The separation into the elements originally composing them, adapts their properties to effect important purposes in the economy of nature, affording to animated beings the power of sustaining and preserving vitality; and to vegetation the means for performing its curious and astonishing functions.

"All are but parts of one stupendous whole."

Among the properties of water which have most frequently formed the topics of disquisition, is that of its salubrity in a *pure* state, with the danger of its use when *impure*. These have been copiously dilated upon by medical men and others who have represented it, in some cases, to be the cause of the most serious maladies; but their opinions have "varied with the varying hour;" and it is rather singular that the most zealous and positive in assertions have generally refrained from explaining their notions of *purity*. From the tenor of their statements, it may, however, be inferred that it chiefly consisted in *transparency;* but strong as may have been their expressions, they did not adduce either facts or experiments, so connecting causes with effects as to demonstrate that, in any instance, particular diseases really proceeded from the use or condition of the water, which was the object of reprobation.

Delusive pretensions have often imposed upon human infirmity; and it has been the common practice of projectors and speculators to employ them for the purpose of realizing their own sordid views. But instinct—that wonderful faculty,—which guides "the half-reasoning elephant," as well as other animals ranging the woods and the fields in search of proper and healthful aliment for their support, furnishes a puzzling problem for solution by the pure-water-philosophers, who so strenuously contend that for water to be salubrious, it must be limpid. When cattle go to a clear stream to allay their thirst, they often abstain from drinking till they have rendered the water turbid by stirring up the sediment with their feet. Will it be unreasonable to infer that nature teaches quadrupeds that in such a state it is not only *wholesome*, but actually *medicinal?* Can any proof be adduced of this practice ever having affected their general health? As the above fact is well known, what reason authorizes the presumption of its producing injurious effects upon mankind? In regard to the salubrity of water, gratuitous assumption unsanctioned by the semblance of probability seems to have been relied upon, rather than fair deduction, or positive demonstration.

In Italy the inhabitants frequently mix salt with water, both to preserve and communicate a flavour to it. Probably the fastidious in this country would object to such an admixture, as incompatible with purity and salubrity; but chemistry teaches us, that during the decay and decomposition of the animal and vegetable substances spread over our fields, *salts* as well as animalculæ are produced, which the descending rains wash from the surface of the soil, and they eventually find their way into the rivers to mingle with their currents. Nevertheless, does any person ever hesitate to drink the water of

a rivulet, or entertain the slightest fear of its proving injurious? Indeed to indulge squeamish notions against its salubrity is obviously unreasonable, when such is the condition in which heaven has bestowed this ineffable blessing upon man.

Perhaps the subsequent statements of two eminent and enlightened chemists may tend to reconcile the fastidious, or prejudiced, by showing to them, that complete *purity* is not a property even of the *purest water* furnished by the usual operations of nature.—"Water is never presented by nature in a state of *complete purity*. Even when collected as it descends in the form of rain, chemical tests detect in it a minute portion of foreign ingredients. And when it has been absorbed by the earth,—has traversed its different strata, and is returned to us by springs, it is found to have acquired various impregnations."* "Rain-water collected in clear vessels in the country, or freshly fallen snow when melted, affords the purest kind of water that can be procured without having recourse to distillation. The water obtained from these sources, however, is not absolutely pure, but contains a portion of carbonic acid and air, absorbed from the atmosphere. It is remarkable that this air is very rich in oxygen."† If such therefore be its natural condition, it may be reasonable to presume that with these qualities, it is best adapted for the most important purposes of animal and vegetable life.

Transparent water, however, being desirable for beverage and many other purposes of human life, it is consequently held in great estimation by the people of every country. In Turkey it is an object of particular attention;

* *Henry's Elements of Chemistry*, vol. ii. p. 516.
† *Turner's Chemistry*, p. 801.

and the inhabitants practice the following simple method of filtration, which shows the facility with which clear water may be obtained, in almost any situation. It consists of two wells formed near to each other, with a communication at their bottoms;—both are lined in the inside with well-beaten clay, or some other substance, to render them impervious to water. When thus prepared, they are nearly filled with gravel and sand, leaving the largest space in that which receives the water intended to be filtered; hence, it is rendered perfectly limpid by descending through the sand and gravel in one well, and rising through similar strata in the other:—the former is generally the highest and most capacious. It will be obvious that the same process may be practised on a small scale by means of casks, or other wooden vessels, having a connection formed in their bottoms by means of a pipe. Such a plan is readily applicable, and would be useful in villages and farm-houses, where the only supply of soft water is derived either from a rivulet in their vicinity, or the rain collected as it flows from the roofs of the buildings. But whether filters be natural or artificial, and whatever modifications may be given to the form of the latter, for the purpose of rendering them attractive to the sight, the same simple principle regulates their agency. In fact many of the artificial filters are constructed by fixing a sponge in a tube, or placing at its orifices bags of sand, pulverized charcoal, &c., through which the water slowly percolates, and flows into a glass or earthen vessel adapted to receive it.

Springs being filters formed by nature, their effects have suggested the useful contrivances, which art employs to imitate her processes; and the filtering reservoirs, constructed at Chelsea, Glasgow, Greenock, and other places, demonstrate the practicability of quickly

purifying large quantities of water. The complete success of these attempts furnishes the strongest evidence, that the population of large cities and towns may not only receive an abundant supply from rivers, but also at the same time be completely deprived of all objectionable matter, before it is conveyed to their houses. At different periods, in consequence of rains, as well as from other causes, mud and animalculæ becoming mixed with it, render its appearance both offensive and unsuitable for many important purposes; hence, on such occasions, filtration is particularly desirable to remove the feculence, and restore the water to that limpid state, which equally gratifies the sight and the taste. As the different establishments at present supply it at a very cheap rate, if it were filtered, and the price proportionally increased, the cost would still be trivial, and it would moreover effectually obviate what has hitherto furnished the chief ground of complaint—its feculent and turbid condition. Probably at no very distant period, the desirable practice of filtering the whole of the water supplied from rivers to the inhabitants of great towns for domestic use may be universally adopted; and if this should be the case, the Water Companies will add another positive benefit to those, which their exertions have heretofore rendered to the community.* Such a measure would likewise tend to dispel the prejudices of the fastidious, as well as prevent the alarms and delusions of schemers and empirics, who are ever on the alert to promote their own views, and attain their own ends, by frightening the timid, or imposing upon the credulous.

* In several recent Acts of Parliament for improving water-works, a clause has been introduced to compel the supplying of filtered water.

CHAPTER XVIII.

The propensity to speculate at the beginning of the present century. Schemes for supplying water to the metropolis. Establishment of various new Water Companies. Competition amongst those situate north of the Thames. Mr. M. Angelo Taylor's Act. Anti-monopoly Association. Project of the Marylebone Select Vestry. Parliamentary Inquiry in 1821; Evidence and Report on the subject. Number and variety of schemes propounded in 1824 and 1825. The Thames' Water Company, its object and magnitude. Mr. Martin's ornamental plan, including fountains, baths, &c. near to Hyde Park.

The beginning of the present century was characterized by the appearance of almost innumerable projects, some of them magnificent, some useful, and not a few that strikingly indicated the futile qualifications of the persons who broached them. Magnitude of cost, utility of purpose, or difficulty in their execution, seemed to be considerations of trivial moment. Schemes for constructing docks, canals, water and gas-works, bridges, and various other objects were daily brought forth in the metropolis, which was the principal theatre of display for wonder-working professors of talent and discovery. Many of these projectors being totally unacquainted with the simplest elements of science, as well as deficient in practical acquirements, nevertheless assumed the title of *civil engineer*, and confidently propounded very expensive plans,—affirming that if the *pecuniary* means for accomplishing them should be furnished the resulting advantages would be incalculable. Pictures so enchanting induced numbers of people to join in random, avaricious speculations; and thus che-

rishing ideas of easily obtaining large fortunes, they indulged in golden dreams until awakened from their reveries by painful disappointment, or positive indigence.

At this era the proposals were made for constructing the East London, West Middlesex, South London and Grand Junction Water-works. The great increase in the number of houses apparently rendered them desirable objects for enterprise; and various circumstances seemed to conspire for ensuring success. Nevertheless, afte enormous sums of money had been expended in constructing them, and evident as was their utility, they at first received scarcely any encouragement. Consequently, to obtain attention and favour, they offered to supply water at a much lower rate than had usually been paid, which occasioned a contest between the *old* and new Water Companies.

The rivalry among the companies continued for several years, at a great expense and loss to all the parties concerned, which rendered it probable that ruin would eventually ensue, if considerations of prudence did not occasion its termination. Circumstances, therefore, strongly impelled them to enter into an agreement, by which each engaged to confine the supply of water to a particular and defined district. The arrangement between the New River and the East London Companies was effected in 1815, by a deed which reciprocally imposed heavy penalties for every violation of its conditions. Though this agreement terminated the competition in the eastern part of the metropolis, yet it continued between the New River, the Chelsea, the West Middlesex and the Grand Junction Companies, till the latter part of the year 1817, when they severally engaged to confine their operations within certain limits; and to avoid interfering with each other. The parties abstained from entering into any

engagement by a specific legal document; but the various districts were then formed, which each company now exclusively supplies; and at the same time they respectively agreed to make compensation for the pipes, that each should give up to the other.

As the Water Companies sustained considerable loss during the ardour of competition, when the several portions of the metropolis that each was exclusively to supply had been determined, they ventured to advance their rates to the same scale of prices as had been willingly paid prior to the contest. This return to the original charge caused much discontent, though its amount afforded merely a very moderate remuneration for useful exertions, and the employment of large capitals. Indeed the majority of such concerns in general have not obtained a profit exceeding, and in many cases not equal to, the common interest of money.

Though the conduct of the Water Companies in raising their rates, encountered severe animadversion from some individuals, yet probably the termination of the contest was an advantage to the public; for during the contest the pavement in the public streets was constantly disturbed by being taken up, either by one party or another, and sometimes by two or three at the same time. Notwithstanding the relaying of the pavement was imperative upon them, the work being generally performed with great celerity, it necessarily left the streets in an unsound state. Hence, additional repairs soon became not only indispensable, but frequent, and the whole expense of these devolved upon the parochial rates, probably increasing them to the respective inhabitants in an equal, if not a greater ratio, than the difference in the price of water. Thus the few individuals, who temporarily had their supply at the lower prices, enjoyed

the trivial advantage at a considerable cost to the whole parish; and such have often been the results of similar competitions. It must also be stated, that at the time the contention existed amongst the Water Companies, the *gas light* establishments were also laying down their mains, so that the streets became in such a condition as to be dangerous for both horses and carriages. The legislature, therefore, passed what is usually called Mr. Michael Angelo Taylor's Act, which, among other useful regulations, restrained all the companies from diturbing the public pavement during the winter months.

Notwithstanding the temporary annoyances and inconveniences attendant upon the early operations of the New Water Companies, the public derived some important permanent benefits from their establishment. During the competition, each urged the peculiar advantages intended to be afforded; but among the principal may be stated,—the *high service*, the *more regular* and *abundant supply* of water *on all occasions*, and at *every season* of the year, by the introduction of large iron pipes through the whole of the metropolis, and these were obvious and positive improvements requiring large capitals and great exertions. Hence, both these having been employed were entitled to that reasonable pecuniary return generally constituting the chief stimulus to either private or public enterprise; and unless the amount of profit be adequate to its support, no trading concern will or can be continued. The inspection of their annual dividends will show that the old Water Companies had not proved to be very lucrative establishments, even when the charge for the supply was the highest; but the reduction during the contest having occasioned great loss to every one of them, necessity imperiously required the restoration of the rates to the standard formerly paid, in order to enable them to

continue their operations. Besides the West Middlesex and Grand Junction Companies found by experience that the sums charged previous to the contest, did not afford a remuneration for the improvements introduced; and in many instances they were irregularly apportioned to the sizes of the houses, as well as to the quantity of water supplied, so that such circumstances led to a survey of their respective districts, and a consequent advance of about twenty-five per cent., upon the average amount of the whole rental.

In the general inspection of the districts, it was discovered that some large houses paid less, and others more, than was right; hence, in equalizing the payments, the advance upon the former appeared to be large, but it did not exceed what was just. Nevertheless, the attempt to regulate and correct the inequality in the rate, as well as to raise it to the requisite amount for affording a reasonable profit, not only produced great dissatisfaction among those who had to pay an advance on the previous charge, but it gave rise to an acrimonious and vexatious resistance. The angry feeling excited by these measures occasioned the Water Companies to be designated as "odious and tyrannical monopolies." Many of the householders united to oppose them, and formed a confederacy, denominated the "*Anti-water-monopoly Association*," who convened public meetings, and decided upon petitions to parliament, complaining of unreasonable demands for the supply of water.

The Select Vestry of Marylebone being among the first and most strenuous opponents on this occasion, moreover, endeavoured to establish a *Parochial* Water Company, and for this purpose a bill was actually introduced to the House of Commons. In fact a suspicion was indulged, and perhaps not improperly, that the primary

object of the principal persons who engaged in resisting and reprobating the Water Companies, was the formation of *Parochial Establishments* for supplying the inhabitants, though the *dearness* of the article formed the avowedly chief cause of dissatisfaction with the complainants. But the public having experienced many expensive instances of Select Vestry *economy*, could they be disposed to conclude, that *cheapness* would have characterized the supply furnished by them? On the contrary, is it not probable that the remedy then proposed would have proved an onerous and costly inconvenience, rather than a benefit to the parishioners?

The circumstances which have been recited occasioned the appointment of a Select Committee of the House of Commons,—"*To inquire into the past and present state of the supply of water to the metropolis, and the laws relating thereto.*" This Committee began the investigation on the 16th of February, 1821, and continued their labours till the 30th of March. The inquiry extended to every fact connected with the origin, capital, and condition, of the different Water Companies;—the quantity of water supplied, with the respective charges for it;—the expenses of all kinds attending their operations;—the number of their tenants, the amount of income, &c. The principal officers belonging to each establishment were very carefully and minutely examined, and a large mass of useful information was obtained. It is also deserving of remark, that the general tenor of the evidence, both oral and documentary, proved that the principal statements respecting the conduct of the different Water Companies were unauthorised. A great portion of the information elicited in the course of this investigation was both novel and interesting to the public; and it had some effect in obviating the prejudices, and abating

the hostile feelings of many individuals, who had previously reprobated and opposed the advance in the rates.

The chief persons concerned in reprehending the conduct, as well as most pertinacious in resisting the claims, of the Water Companies, were also examined by the Committee, and their own testimony tended to prove that the increase of the rate beyond the amount paid in 1810, was almost the sole ground of their dissatisfaction. It is remarkable too, that the reasonableness and propriety of the advance seemed never to have entered their minds; moreover, their own statements evinced, that harshly and profusely as they had bestowed censure and vituperation upon the companies, not a single fact was adduced to show their conduct to be justly deserving of complaint. Various other circumstances attendant on this memorable investigation are entitled to notice. The chairman of the general committee of the "*Anti-water-monopoly Association*," was likewise the chairman of the Select Committee of the House of Commons, for investigating the subject; and the most active and vociferous opponents of the increase of the rate, were actually persons who either held a *lucrative* place in a *public* office, or belonged to the *medical* profession, some of whom it appeared, though complainants, really paid *less* than their neighbours for the quantity of water supplied to them!

The Committee having obtained all the requisite evidence, several weeks were devoted to reviewing and considering the whole, with reference to all its bearings on the subject of complaint.

Their Report was delivered to the House of Commons on the 18th of May, 1821; its purport evinced the attention and care bestowed upon the investigation, and the conclusions were generally in favour of the Water Companies.

The following extracts from this document form the most important portion of its contents, and will place the subject in a clear and striking point of view :—

"The question fairly stated appears to Your Committee to resolve itself into these—

"1st. Is there any improvement in the supply, and how far is it proportioned to the increase in the demand?

"2d. Could that improvement have been obtained, or could it now be obtained upon terms so much more favourable, as to set the increase of rate, at present demanded, in the light of an extravagant overcharge?

"In resting the case on these grounds, it will appear that Your Committee do not treat it as one in which it is simply to be considered, what will remunerate the companies for their actual outlay, but as a case for fair adjustment between the companies and the public, in which it is proposed to cast upon the latter no greater portion of a losing adventure, than is equivalent to the advantages which they actually derive from it, and to leave upon the former the remaining burthen of a loss incurred in trade.

"Upon the first of the two questions, Your Committee are of opinion, that a material improvement has taken place in the supply, both in respect to *abundance* and *certainty;* and which is not without its weight, as a consideration of *public utility*, it is extended, in its improved state, *to large districts* in the neighbourhood of the metropolis, which *were not* before supplied.

"Your Committee are inclined to believe, that the *quantity* of water, *now delivered* to houses, is in about the proportion of five to four, to that which *they formerly received;* and that, taken with the *increased regularity* and *certainty* of supply, the advantage to the consumers

may be fairly stated to be in that proportion, with *the further benefit* that the *security against fire* is *increased*, and that by the establishment of communications between their works, the powers of the companies may be brought in aid of each other, in case of emergency. Your Committee have no hesitation in stating their opinion, that the *present supply of water to London is very superior to that enjoyed by any other city in Europe*; and that the preservation of that supply, in its present state, is by far the most important object involved in the questions under consideration. It remains to be determined, whether these advantages have been obtained, at a greater expense, than it was necessary, with good management, to have bestowed upon them; and consequently, whether it is just, or to what extent it is just, to lay an increased charge upon the public in respect of them."

The Report was not only long and minute, but presented a variety of suggestions and considerations, of which the following were most pertinent to the principal subjects of complaint.—"The question for the legislature being always this, and only this, could the public be served *cheaper at a fair rate of profit?* for without such a rate of profit, a competition would not be practicable."—"They feel satisfied, however, that the question lies within narrower limits than is supposed by those, who object to the claims of the companies. They are not prepared to state that *the rates of* 1810, *would*, upon the principles above recited, *be an adequate payment for the present supply*."—"Your Committee are desirous, that for the sake of a final good understanding, between the public and bodies of men, whose property is *most usefully employed in the public service*, the question of *quantum* of charge should be disengaged

from other questions, with which it is at present mixed; and which tend to produce dispositions, unfavourable to a candid and liberal consideration of it."

The House of Commons ordered the Report and Evidence to be printed; and it formed a volume of nearly 250 folio pages. Candour, judgment, and discrimination characterized the Report, and the Evidence abounded with useful facts, that never before had been given to the public; but at the same time, it furnished a palpably striking instance of the captious feelings, sordid motives, and trivial circumstances, which have often originated parliamentary proceedings, as well as occasioned both to individuals and the public great trouble and expense. This investigation, however, afforded so large a portion of valuable information respecting the Water Companies of London, as to form a very interesting epoch in their history.

The multiplicity of useful and costly works in Great Britain demonstrate the diversified ingenuity and persevering industry employed to construct them. For their accomplishment large capitals are indispensable and commonly surpassing the power of one or two individuals to furnish. Exigences of this description have therefore encouraged the forming of associations for realizing different projects conducive to the public welfare. The utility of these was not only obvious, but they also required the aid of science, as well as a considerable share of skill to render them effective. These useful contrivances, however, gave rise to many of a different description, and originating in sordid motives.

Remarkable as was the early part of the present century for adventurous speculation and delusion, perhaps the number, variety, and extent of the schemes propounded in 1824 and 1825, far exceeded those of any previous era in

the annals of any country. Extravagant panegyric alike decorated those devised for important, or frivolous objects; indeed all were indiscriminately urged upon public attention as calculated to afford the means of obtaining either large pecuniary gain, or fair and satisfactory remuneration, if persons would venture to embark their property in the projected enterprises. Daily and almost hourly appeared different Joint Stock Companies, formed professedly and ostensibly for realizing the flattering, but illusive representations; and astounding as may seem the statement, during the years 1824 and 1825, more than six hundred associations of this description originated with different schemers. Besides the more effectually to obviate suspicions respecting their real object, and make a favourable impression upon the public as to their great value, the prospectuses of the respective plans were frequently emblazoned with the names of Legislators, Fellows of the Royal Society, and other institutions.* Indeed some of the persons alluded to rendered themselves conspicuous on various occasions, by affording their testimony to the merits of deceptive projects; but events subsequently developed the motives which actuated these *honourable* and *philosophical* personages, demonstrating them to be palpably and reprehensibly sordid; and that the tempo-

* In reference to this statement much amusing information may be derived from the perusal of the Evidence given to a Committee of the House of Commons concerning the Arigna scheme, as well as from Mr. Babbage's work entitled "*The Decline of Science in England*;" in which it is shown that *pecuniary* rather than *intellectual* qualifications enable many persons to become members of *Royal* and other Societies. Mr. B. gives an account of the mode by which these *philosophers* obtain the various letters to append to their names "to almost a comet's length of tail," and likewise the cost to a farthing of each letter thus purchased, for pompous or interested display.

rary personal advantage of a few individuals, alone prompted to the formation of a majority of the companies. At least five hundred of the number have long ceased to exist; and are now known and remembered only for the great pecuniary losses, ruin, and sufferings of many worthy individuals, whose confiding honesty, and lamentable credulity, exposed them to become the victims of such nefarious impositions.

Among the multitude of enterprises, which characterized a period so prolific of contrivances, a grand and costly scheme for water-works appeared. This occurred at the latter part of the year 1824, when a company was announced, having the designation of "*The Thames' Water Company*,"—its avowed purpose being to supply the metropolis with water from the river Thames. The prospectus was ingenious and plausible, abounding with the usual hyperbolical professions, which at that time exuberantly distinguished such productions. It commenced by vaunting of superiority as "possessing powers and advantages calculated not only to benefit the public in an essential manner, but also to ensure a fair return to those who may invest capital in it, which can only be accomplished *by means not hitherto acted upon*, or *proposed*." Allusions were made "to evils too notorious to be disputed, the public being supplied either with water *far inferior in quality* to Thames' water, or such as is drawn from the river after it has become contaminated by torrents of impure matter of various kinds;—and that under the existing state of things, no option is left to the consumer of this great necessary of life, either as to terms or quality." It then dilated upon "the vast importance of a copious and regular supply of *pure* water, to the *health*, *comfort*, or *safety* of the inhabitants of the metropolis;" and as a conclusion to the climax, urged

upon the opulent, the pecuniary support of "the *best* mode of producing a regular, equal, and effective supply, on *fair* and *liberal* terms!"

Confident assertions and great pretensions—the usual concomitants of empiricism—abounded on this occasion; and how often has similar presumption, though unqualified by any epithets savouring of diffidence, been construed as evidence of superior capabilities? The scheme delineated by the projectors of the *new* Water Company was adapted to excite attention, both as regarded its magnitude, and the peculiarity of its means for attaining the object proposed. Its ostensible and professed purpose was to procure "pure and unpolluted water" from a place between Richmond and Brentford, and to convey it thence by a subterraneous aqueduct, six feet in diameter and more than nine miles in length, to an elevated spot at Hampstead Hill, or its vicinity, which is 437 feet above low water mark at Hammersmith. The tunnel was to be formed wholly with bricks; besides at different stations and heights, large reservoirs were to be constructed, to which engine shafts should be perpendicularly sunk, so as to meet the aqueduct. The several reservoirs were to be ranged at various altitudes, one above another, like so many steps; steam-engines were to be employed to raise the water from each reservoir in succession, till it reached the highest point, from which it was intended to be afterwards distributed to every part of the metropolis.

The above description contains a general outline of the plan proposed by the projectors of the "Thames' Water Company;" and the scheme being elaborate, the capital required for effecting its object must of course be commensurate. Hence, the sum of 750,000*l.* was stated to be the estimated amount of its cost; but large as was the

estimate, if the expense of executing similar great works, may be taken as a criterion for anticipating the probable cost of such an undertaking, perhaps it will not be an extravagant conclusion, that twice or thrice the sum mentioned, would have been found necessary for its final completion.

'Strong and pointed as were the allusions to the defects and inefficiency of the other establishments which then supplied, and still supply the metropolis, it may not be unreasonable to entertain doubts, whether the statements of the prospectus had the sanction of truth or probability, and that the proposed undertaking "appeared more likely to combine *public utility* with adequate and *fair remuneration* to individuals engaged in it, than any work of the sort hitherto projected." Indeed, if this artfully contrived scheme had been carried into effect, it is not improbable, that the public would have been actually placed in the very predicament, which the projectors professed to aim at obviating; for though they alluded to "no option being left to the consumer of this great necessary of life, as to *terms* or *quality*," yet one of the avowed purposes of their plan was, that "from the *grand* reservoir, *the different Water Companies* should be *obliged* to lay down aqueducts to their own respective reservoirs, and thus supply the metropolis with *pure* water!" Hence, it will be obvious, that whilst reflecting on all the other establishments, an attempt was actually made to introduce a scheme, for rendering them, and consequently the public, subservient to the cupidity or caprice of one Joint Stock Company, who with professions of liberality, aspired to possess the power of compelling all the other Water Companies to take the water for distribution, *solely from their* reservoirs, and pay a "*fair remuneration*" for it to them alone! If this proposition cannot be admired

for its modesty, it will afford a striking specimen of the confident assertions employed on the occasion, and may lead to a reasonable and just inference concerning the peculiar advantages of this much applauded scheme; for is it not in the highest degree probable that it would have tended to increase the price of water to *double*, *treble*, or perhaps, *quadruple*, the sum previously paid?

Though specious statements and fascinating language were employed to pourtray the "public importance," and pecuniary advantages of this magnificent and comprehensive scheme, yet wealthy speculators did not participate in the *enlightened* views of the projectors, or appreciate their *philosophic* labours so highly, as to induce them to support the *grand* undertaking. The projectors boldly averred that "no doubt need be entertained of the practicability of the plan, as it was simply a *new combination* of works, *well-tried* and resting on the basis of experience;" and they also referred to "the aqueducts of Rome as the most indestructible monuments of that city's greatness;" nevertheless, these asseverations and appeals proved ineffective, so that the anticipations fondly indulged, were doomed to end in disappointment. Perhaps, its failure was a fortunate circumstance for the public in many respects; for various considerations render the supposition probable that it would have proved the most expensive undertaking of the kind ever projected in this country; and though its execution might have enriched engineers, contractors, and a few others, yet many of the shareholders would, as in numerous similar cases, probably have been reduced to indigence and distress. Besides, however plausible might be the pretensions urged, or pompous the phraseology employed, not a single cogent and satisfactory reason was adduced, to justify a conclusion, that, even if the scheme had been

accomplished, the supply of water to the metropolis would be either more certain, more ample, or purer in quality, than the previously existing establishments had supplied to the inhabitants, at a very moderate price.

At a subsequent period another splendid scheme for conveying water to a part of the metropolis, emanated from Mr. John Martin, who has distinguished himself by some ingenious designs for illustrating the poetry of Milton, and various other subjects. It was addressed to the Legislature and the Public, with the title of a "Plan for supplying with pure water, and materially beautifying the Western End of the Metropolis;" and the projector disclaimed all views of private advantage from the realization of his design," which chiefly aimed at the public good by superadding beauty to utility. Some elegant drawings and a map accompanied the description.

For effecting the different objects contemplated by Mr. Martin, the water was to be obtained either from a branch of the river Colne, or from the river itself, and conveyed to a reservoir at Paddington. If it should be taken from the former source, the point indicated for the purpose was a place situate "betwixt Hillingdon and Cowley, whence it might pass by the shortest cut to the Paddington Canal, and afterwards run for a considerable distance almost close to it, as well as parallel to its bank till it entered the reservoir;—the advantage of this course affording a level already ascertained, besides the canal facilitating the transportation of the necessary materials. In a few places, where the banks of the latter were much elevated above the immediately adjoining level, aqueducts, or some other means of conveying the water, would be necessary." However, Mr. Martin preferred "taking the water from the Colne about three quarters of a mile

to the north-east of Denham, just above the point where the Paddington Canal crosses it, thence continuing its course across Uxbridge Common, and through Furtherfield to near the northern side of Downbarn Hill, till it was brought close to the bank of the canal, near to the south side of Massenden Hill, and then running nearly parallel with the canal to Paddington. The practicability of this course, and its advantages over that first mentioned, consist in its being not only shorter, but giving the supply of water nearer the source, from a larger and purer stream, having an unfailing quantity. The stream would thus flow into the reservoir at Paddington, at an elevation of nearly eighty feet above high water in the Thames, which would permit its distribution, without the aid of a steam-engine, to all the western part of the metropolis, excepting only those parts of Paddington and Mary-le-bone, situate above its level. For supplying such parts with water, an engine of small power might be sufficient; but a considerably greater quantity of water was to be taken from the Colne than the domestic consumption required, so as to be employed in the following manner."

"At a point in the aqueduct, a little above the reservoir, it was proposed that there should be a considerable fall of water, over a dam, which, at another point, should fill a bath 500 feet in length, by 150 in width. This would permit a thousand persons at once to enjoy the comfort and salubrity of bathing, for which desirable purpose there is at present no convenience. The bath might be surrounded by small wooden boxes for the use of the bathers; and for this expense a remuneration would be afforded, by the imposition of a very small sum upon each bather. The whole might be surrounded with a plantation.

"Having been conveyed under the road, the stream might, at one point be spread into an ornamental water, with a water-fall. But in order to prevent the road becoming a line of buildings so as to form a street, and thus shut out from the parks the influx of pure air from the country, it was proposed, at another point, to erect a range of buildings, which should terminate the western end of Oxford Street, presenting an imposing appearance at that entrance to the metropolis. The houses would in this case command a view into the Parks, Kensington Gardens, &c., which would render them desirable residences." It was likewise intended that the course of the water should "pass under the Uxbridge Road into Kensington Gardens, and the Serpentine Canal, where at a certain point might be constructed a water-fall; and thus the additional stream would have the effect of rendering more beautiful that spot which has already many striking beauties."—Having been conveyed into Hyde Park, it was designed that "the current should be spread into an ornamental water and water-fall, where a small island would give a view," was represented in a sketch.

From Hyde Park, Mr. Martin proposed for the water to flow through a subterraneous conduit "to the gardens of Buckingham Palace, that the stream might be made to disembogue as from a natural cavern, and spread itself. Hence, passing under Constitution Hill into the Green Park, the current to be conveyed under the Mall into the ornamental canal in St. James's Park; at the two extremities of which it was proposed to introduce fountains, formed and planted around with shrubs and trees; the stream having its final exit into the Thames at Whitehall Stairs."

Mr. Martin's scheme likewise comprised the supplying of "a small quantity of water that should be poured

into the Paddington Canal from the river Colne at Cowley, for the purpose of allowing a stream to flow from the canal into the basins in the Regent's Park," to remedy their almost stagnant condition. Such is the outline of the fanciful plan of the celebrated artist, who gratuitously gave it to the public, with the designs intended for its appropriate decoration, though no attempt was made to realize his views. That part of it which relates to the construction of public baths would not only have formed a very desirable addition to the conveniences of the metropolis, but also have greatly conduced to obviate the accidents and annoyances attendant upon the practice of bathing in the Serpentine.

The possessor of a fervid imagination is generally prone to indulge its fascinating reveries, though frequently illusory, as well as incongruous with the calm and grave deductions of reason from a careful examination of facts by the light of science. Vigorous and creative, the enchanting faculty, luxuriating in agreeable fictions, endeavours "to give to airy nothing a local habitation" where realities cannot exist; whilst on the contrary, reason sedately and rigidly scrutinizes the peculiar circumstances of a scheme to ascertain its possibility, prior to forming a conclusion concerning its merits, and urging its adoption. Hence, justice and candour combine to dictate the remark, that considerable as was the inventive power exhibited by the ingenious painter in delineating the outline of his picture, or the skill employed in its colouring and embellishment, perhaps some almost insuperable difficulties would tend to prevent the accomplishment of his objects.

Previous to Mr. Martin propounding his imaginative scheme for embellishing the metropolis, and supplying its inhabitants with clear and salubrious water from the river Colne, the same source had been suggested by other

persons, and at several different times, but on a careful inquiry into all the circumstances relating to its condition, the reasons against its adoption have generally preponderated. According to the representations of those who have had frequent opportunities of inspecting it, in every state and season of the year, the quantity of water usually flowing in its channel, would not be sufficient for all the different purposes contemplated by Mr. Martin. Besides, it has also been stated by the same persons, that although its water may be sometimes clearer than that of the Thames, yet during rains and the winter months, various causes render it much more foul and turbid, and that it will not even clarify itself for a long time, by depositing the clayey and other matter casually mixed with it. Hence, probably in the dry seasons, the projected fountains and water-falls would fail of effect, from a deficiency of water; whilst on the contrary, when the current might be abundant, its condition would not only be quite unfit for domestic purposes, but on its being ejected from the ornamental fountains, and picturesque water-falls, in a muddy or coloured state, the appearance would be rather offensive than pleasing. If, however, the fertile genius of the painter does not, in this instance render him conspicuous as a philosopher, his patriotism was laudable, and he has the consolation of ránking with "eminent engineers" and other persons, who have occasionally displayed not only a want of the necessary scientific and practical knowledge, but even of useful consideration and ordinary sagacity, when engaged either in projecting or executing important public works. The scheme of Mr. Martin may be plausible and tasteful, but perhaps circumstances will ever prevent it from being realized, though embracing a considerable portion of architectural beauty and elegant design, indicative of the cultivated talent of the artist.

CHAPTER XIX.

Attempt in 1827 to create alarm concerning the impure and dangerous condition of the Thames. Publication of *The Dolphin;* its imputations upon the Grand Junction Water Company and the Gas Works. Public Meeting and Petitions to Parliament. Appointment of Commissioners to inquire into the state of supply of Water to the Metropolis, and their tardiness in discharging the duties. Singular statements of Fishermen, Medical Practitioners, and Mr. Mills. His representations of the structure of the bed of the river, and state of the water as likely to become putrescent. Confession that his own object, as well as that of the author of *The Dolphin,* was the establishment of a new Water Company. Analysis of the different specimens of water by Dr. Bostock, Dr. Pearson, and others; the results. Absurd notions of its being insalubrious. Imputation of monopoly to the Water Companies unjust. The conduct of the Grand Junction Company with regard to their rates. Report of the Commissioners; its partiality, and inconsistency with facts.

Among the diversity of substances composing the magnificent globe that we inhabit, water is evidently one of the most universally useful and extensively beneficial. It is not only essential to the existence of both the animal and vegetable creation, but conducive to the production of a large share of the comforts and conveniences enjoyed by civilized men. To afford such a plentiful supply of this necessary article, in a salubrious and clear state, as may be adequate to all the wants and purposes of the large population congregated in the great metropolis of Britain, is an object of no ordinary magnitude; and therefore the operations on which it chiefly depends ought not to be made the sport of sordid schemers or ignorant adventurers.*

* The author of this work wrote a pamphlet in June 1828, to expose the delusive nature of some projects for Gas Lighting, and

The years 1827 and 1828 were signalized by an attempt to create an alarm concerning the dangerous condition of the Thames; and the most preposterous stories seemed to receive implicit credit from legislators, medical practitioners, and others, having the reputation of being *eminent* for sagacity and information. The effect produced on this occasion afforded a striking instance of the influence of prejudice, in suspending the exercise of reason amongst a large portion of the more cultivated class of the community. Indeed, credulity was so conspicuous, as to indicate a state of intellect nearly resembling that of the sombre period when the existence of ghosts, fairies, and witches, formed a part of the popular belief! A variety of facts, however, concur in demonstrating that the *alarm* about the *deleterious* qualities of the water did not emanate either from an accurate knowledge of its real condition, or a laudable desire to benefit the public, and was merely one of the delusions which have so often been practised to serve private purposes. The subsequent analysis of the erroneous statements which were then industriously disseminated will, it is hoped, tend to dispel the unfounded apprehensions that many have been led to indulge. Besides, a detail of the circumstances may be in other respects useful, inasmuch as some of the indivi-

appended to it a few remarks on the statements in the Report of the Commissioners appointed to inquire into the Supply of Water to the Metropolis. During the following month he also regularly attended at the House of Commons to listen to the evidence adduced to the Select Committee, of which Sir F. Burdett was chairman. His observations on that occasion led him to scrutinize the circumstances very minutely. The result formed another publication, entitled "*The Water Question, by a Water Drinker*;" and from this several paragraphs are adopted in the two subsequent chapters.

duals concerned in originating the panic, have persevered in their efforts during several years, at an expense to the nation of at least ten thousand pounds, and probably a much larger sum, exclusive of private contributions, and its great cost to the Water Companies.

That the delusion originated for the purpose of being made subservient to establishing *new water-works*, was clearly demonstrated by several incidents, and confirmed by the positive declarations of the persons concerned. Hence, to produce an impression favourable to the attainment of their object, the Thames was represented to be almost saturated with different kinds of injurious and offensive substances, but particularly with "*the poisonous refuse of gas-works!*" This erroneous assertion with various others, appeared in a small pamphlet, written in the most acrimonious style, by one of the projectors, and published in March, 1827. The publication had for its title—"*The Dolphin*"—the term employed to designate the structures inclosing the end of the pipes by which some of the water-works obtained the supply from the Thames. It had a lithographed frontispiece representing Chelsea Hospital, and the Grand Junction Works, with the great sewer flowing between them, directly against the Dolphin, but *without exhibiting the high mound* that wholly prevented "the foul stream" from approaching even near to it.

Though the author dilated on the Water Companies generally, denominating them "the *confederated Companies;*" yet the most serious of his charges and remarks were directed against the Grand Junction Company. This very Company, however, had early in 1825 commenced works at a cost of 50,000*l.* for improving their supply to the public, *nearly two years before the appear-*

ance of his pamphlet. The Chelsea Company had likewise been similarly employed many months before he "set about collecting together his *facts*," as he denominated statements having a striking resemblance to *fables!*

The writer began by affirming that "he came to the determination of directing the attention of the public, to the bad quality of the water furnished by *one* of the five companies which had partitioned the town between them, and had thereby established a *monopoly* of an element of nature, and prime necessary of life.—But before he carried that determination into execution, he thought proper to address a letter to Sir Francis Burdett, in which he pointed out to him *the evils* which a *monopoly* of an article designated by the great Mead as 'the vehicle of all our nourishment,' had brought upon his constituents; and expressed a confident hope, that he would further the object he had in view, by calling the attention of the House of Commons to so crying a grievance. To this letter Sir Francis replied, recommending a public meeting, and a petition to Parliament; and stated that he should be happy to lend a helping hand towards the overthrow of so *mischievous* and *unprincipled* a confederacy." But to justify the use of such epithets certainly required the support of well-authenticated facts, not having even the shadow of doubt attached to their credibility; but whether this afterwards proved to be the case, or the conduct of the Water Companies was deserving of censure will appear from the evidence adduced.

Agreeably to the Baronet's suggestion, a public meeting was convened, which determined upon a series of resolutions, and petitions to both Houses of Parliament. It is remarkable, that in the resolutions and petitions of

this assemblage, the *different allegations* of the author of the Dolphin were not only embodied, but even *his expressions adopted*; besides, he was also one of the Committee for carrying them into effect, and became their Secretary.* Subsequently, motions were made in the House of Lords by Lord Wharncliffe; and in the House of Commons by Sir F. Burdett—"Praying that his Majesty will be graciously pleased to order a commission to be issued to inquire into the supply of water in the western parts of the metropolis." Both these motions being agreed to,—a commission was issued, dated July, 1827, appointing Dr. Roget, Mr. Brande of the Royal Institution, and Mr. Telford the engineer, the commissioners for the inquiry, investing them with power to call before them *any persons* who might be able to elucidate the subject of inquiry, and also *to administer an oath*, if they deemed it requisite; but the inquiry was delayed by different circumstances, until the month of March in the subsequent year.

Perseverance in the pursuit of useful objects is always commendable, and to attain the laudable end which the author of the Dolphin professes to have had in view, he states, that "he thought right to address a letter to a few of our *eminent professional men*, and *to wait* upon them with a specimen of *the said water*," observing, that "they would much oblige him, if they would inform him whether they considered it fit for the breakfast table, and to be used in the making of bread, puddings, broth, soups, &c., and in boiling meat and vegetables. Or whether, on the contrary, they did not consider the daily

* The meeting amounted to about sixty persons, consisting of a few noblemen, gentlemen—and not a small proportion of medical practitioners—a water-work projecting engineer, and the author,—Sir F. Burdett being chairman.

use of such water had a direct and positive tendency to engender those diseases to which the inhabitants of so thickly a peopled city as Westminster are especially liable. But this candid person, who professed to be so earnest in his efforts for supplying "the western part of the metropolis" with "pure and wholesome water," avoids mentioning *where*, and *under what circumstances*, he *collected* his *specimens* of *Thames' water* to *exhibit* to the "eminent professional men" on whom he waited. It is also rather singular that not one of these circumstances is ever either *elucidated*, or even *alluded* to, in any subsequent part of the inquiry, although the author of the "Dolphin" furnished so great a portion of the evidence on which the Commissioners afterwards founded their Report.

Much importance having been attached to the Inquiry of the Commissioners, as well as the public interested in the result, the exertions of one person to aid the author of the "Dolphin," ought not to pass without particular notice. Indeed the latter frequently quotes him, and not only acknowledges his obligations, but also denominates him his "venturous and intelligent correspondent."* This individual delivered a *written* statement recounting how he employed himself in watching the water that flowed from different sewers, and counting the dead dogs, cats, rats, and fish, which happened to be left on the mud, at the side of the river, on the retiring of the tides. His discoveries of this kind must certainly have amused, if they did not afford useful information to, the Commissioners, for he related that during several months diligent observation, the number of defunct animals actually seen by him, amounted to "*two* dead dogs, *one* dead

* *Minutes of Evidence*, p. 149.

cat, *seven* dead rats, besides some putrid fish;"—he also affirmed that he really saw "*gas oil, and floating gas*"—invisible as the latter fluid is known to be by the ordinary organs of sight! Will it be unfair to surmise that this inspector of the sewers probably furnished the identical bottle of water, the sight of which was asserted greatly to agitate Mr. Abernethy, as well as that *sent* to the successor of Mr. Accum to be analysed? In fact, he stated that he "took a bottle of the filth as it came out of the Fleet Ditch sewer."*

Whether the medical men were aware, when they wrote their replies to the author, that their *lucid* and *instructive* communications were intended to be made public, may admit of a doubt; but persons who read them, with a view to obtain accurate and satisfactory information respecting the genuine properties of the water supplied to the metropolis, must have been greatly disappointed. With respect to the water *sent* for their inspection, one of the "*eminent men*" declared that he could "not find terms sufficiently expressive of the *awful effects* it may be *likely* to *produce* upon the *health* and even *lives* of the inhabitants of the metropolis;" another

* These instances will enable every unprejudiced person to appreciate the sagacity and other qualifications of this active and "intelligent" favourite of the author of the "Memoir," but to corroborate what he had stated to the Commissioners, as *facts*, in August, 1829, he addressed a letter to the Morning Advertiser, averring that he "*saw* a barge loaded with *barrels of gas* from the Horseferry Road, and the stinking *poisonous* cargo was sufficient to poison all the fish between Greenwich and Woolwich!" Instead, however, of these being "barrels of *gas*," they were really barrels of *tar*. This proved his ignorance of the nature of gas, and all that the fishermen knew of its properties was, that "the *same smell* came out of the hatches." Such evidence seems, however, to have been quite satisfactory to the *scientific* Commissioners, by its forming a "prominent" topic in their Report!

had "no *doubt* of a continued use of such water, without filtering or depuration, being, *in the end*, *capable of producing deleterious effects*;"—a third was "not *prepared to prove* that *its influence* on the *health* of the inhabitants of the west end of the town *had been deleterious*, but *conceives* it *likely to become so*;" but another candidly affirmed that "whether this impure state of the water had *any* influence on the *health* of the inhabitants of Westminster, was *a question* that *would admit of much controversy*." These are fair specimens of the opinions expressed by the "eminent professional men" on the subject; and some of them were also *authors*, who had written on "*Diet* and *Regimen*," "*Indigestion*," &c.; but not one actually assigned a single *scientific* reason for his opinions, or for *believing* that the Thames' water was so contaminated and deteriorated in its general and usual state as to be "unfit for domestic purposes."

As the author of the Dolphin's account of his interview with one practitioner exhibits a remarkable instance of his talent at ratiocination, it shall be given in his own words:—"My first visit was to Mr. Abernethy, of whom I had heard much, but never before had the pleasure of seeing. Scarcely had I put the letter into his hand, when I *unfortunately held up the specimen bottle*, and asked him whether he thought *such water* could be wholesome? Never shall I forget the *countenance* of this *eminent* man at that moment! The very *sight* of the turbid fluid seemed to occasion a *turmoil in his stomach*. He began pacing the room backward and forward, and the only words I could extract from him were, '*How can you ask me such a question? How can you ask me such a question? There is such a thing as common sense! There is such a thing as common sense!*'" Such were the ludicrous circumstances of this *rencontre*; and in

the plenitude of his joy at having obtained so much useful information, by the *luminous* remarks of the eminent man, the sagacious author judiciously affirms:—"I left his house *satisfied that I had established my case!*" How ready at a conclusion! But the admirable logician thus continues:—"In a communication which I have *since* been favoured with from Mr. Abernethy, he has had the goodness to *confirm my interpretation* of his exclamation, and to say, that he considers the question to be one which *may* be '*terminable by the common sense of the public!*'"

Moreover, with the view of displaying his great *knowledge*, or rather *erudition*, respecting the injurious properties of Thames' water, the author gravely affirmed, that "without pure air and pure water the inhabitants of large cities cannot enjoy a sound mind in a sound body;" but to *prove* the correctness of his principle, lacking, it is presumed, *reasons* and *arguments* of his own, he merely cites the *opinions* and *conjectures* of some antiquated medical and political writers, with a few of modern date. Proofs of this kind are easily obtained; but Hippocrates, Sir William Temple, Dr. Mead, Dr. Trotter, Sir John Sinclair, and others whom he names, will not be deemed infallible authorities in this "age of intellect;" for thinking people are not disposed to rely upon the gratuitous *assertions* or *opinions* of any men, whether of former ages or the present, unless they are corroborated by *good reasons*, *cogent arguments*, or the irresistible evidence of *facts*. Modern science has taught us to ascertain the *qualities* of both "*air and water*" by accurate analysis; and a few pages of the writings of Priestley, Lavoisier, and Davy, will probably afford more useful and satisfactory information relative to these "elements of life," than all the ponderous volumes that were written

by those who are cited to sanction the author's efforts to *alarm*, rather than to *illuminate*, the wealthy and polished residents of "the western parts of the metropolis" about Thames' water!

The author also stated that "as soon as he had made up his mind to call the attention of the public to the subject, he caused a quantity of the water, as it ran from the (Grand Junction) Company's pipes, to be sealed up *in the presence* of one of their own Directors, and he sent it to the successor of Mr. Accum, with a letter requesting him to analyse the water *sent*, and to say whether he considered it to be clear, pure, free from foreign matter, and excellent for all culinary and domestic purposes." Suffice it to say that his answer was, that "the water *sent* for assay was found to be *loaded* with *decomposed* vegetable matter; and in such quantity as to be unfit for use without tedious purifications!" Such an answer was doubtless perfectly satisfactory to the philosopher who sent it, and strictly accordant with his expectations at the time.

Another fact is deserving of particular notice, that alarming as the condition of the Thames was stated to be, and though the Commissioners were appointed in July, 1827, yet their first meeting did not take place till the November following, when they applied to the Secretary of State requesting to have "*the assistance of some person conversant with the business of engineering*, who was *known* to them, and in whom *they* can place *perfect confidence*, as their *secretary!*" This application not only excited surprise, but the reply to it affirmed, that the object of the commission was *inquiry*, and did not contemplate that any *new works* should be undertaken. However, the Commissioners appear to have entertained the idea of "*new works*" before they had

even begun their *inquisitive* labours: it evidently pervaded their proceedings; which concluded with the same enterprising views, although all the truly scientific evidence proved the *purity* and *wholesomeness* of the water, and they actually reported *the supply to be abundant!*

Alarmingly contaminated, and dangerous to the health of the inhabitants as the condition of the Thames had been described, nevertheless, the Inquiring Commissioners again delayed their investigation till March, 1828! When they met to enter upon the important scrutiny, it may be right to remark that one of the first persons to whom they applied was the author of "*The Dolphin.*" As his pamphlet mainly consisted of the antiquated or unfounded notions of medical men, mixed up with ridiculous fictions taken from newspapers, and bold, palpable misrepresentations, which he denominated "a faint picture," it might naturally be presumed that competent artists would give it proper shading and colouring to produce its intended effect. Agreeably, therefore, to their request, he furnished "*a list of persons to be examined,*" as well as "*another list of persons who had remedies to propose;*"—thus rendering it evident that *remedies* were actually contrived, even before the Inquiry had ascertained the existence of evils to which they might be applicable. The same person also reprinted his pamphlet, with the title of "Memoir addressed to the Commissioners," &c., in which among other assertions equally *veracious,* he stated that "the Commissioners of Sewers have endeavoured to prevent the refuse of the Gas-works from escaping into the river; but from the immense quantity now used, *it inevitably finds its way thither;* and not long ago it was proved, upon a trial, that *a horse was actually poisoned* by drinking water, impregnated with the refuse of the Gas-works in Horseferry Road!"

To these were subjoined some "wondrous tales" which had appeared in the "daily papers" about the destruction of fish,—the death of a boy, &c., by the contaminated water, but none of these were authenticated with a signature, and some had not the semblance of probability; but they were given as "*facts!*"

The three Commissioners being Fellows of the Royal Society, and consequently ranking among philosophers, the public therefore expected from them a rigid scrutiny of all the circumstances connected with such extraordinary assertions as had been made. Fishermen, fishmongers, and others, were indeed examined, or delivered *written* statements, but they displayed a striking deficiency of knowledge and intelligence. All of them concurred in ascribing the most horrible and alarming consequences to "the *gas* and the steam-boats!" The inspector at Billingsgate affirmed the Thames' water to be so poisonous that neither "roach, plaice, flounders, salmon, shad, eels, dace, dabs," &c. could exist in it;—that "the fishermen could get plenty of *dead* flounders but no live ones;" but that "white bait were certainly obtained in greater abundance than formerly!"—an affirmation proving his former affirmation to be incredible.

Another person's testimony was of a similar nature, for he boldly averred it to be impossible "to keep fish *alive* in Thames' water,"—"he had known three parts of a cargo of eels die by the *gas water!*" and likewise "a vessel lose all their eels in one night!" Appalling, however, as was his account of the extensive fatality to the fishes, the same *knowing* and *consistent* individual declared, that "*he used the same water for tea,*—it was clear enough for tea!" But to finish this curious picture of the bad state of the Thames, one of them represented

the poor fishes to be so uncomfortable in their native element, that they actually "jumped out of the water, and got on to pieces of wood that were floating," to avoid its fatal effects!* Can any man, possessing the slightest portion of sagacity or discrimination, be unable to form a decision concerning the credibility of statements so ridiculously preposterous? Yet absurdities so palpable seem to have been implicitly believed by the philosophical Commissioners, inasmuch as they "*prominently*" figured in their Report!

Singular and irrational as the preceding statements may appear, the disciples of Æsculapius endeavoured to surpass them, by stories equally inconsistent and amusing. One represented the water of the Thames to be very "impure, offensive, and muddy, but he did not use it except for *washing*!"† A second depicted it as a "horrible mixture—a mass of impurity, produced by all that is corruptible in the animal and vegetable world, together with the noxious filth of gas and other manufactories"—he had even "seen shrimps in the water?" But when

* Soon after the Report was printed, the water was removed from the reservoir in the Green Park, and the canal at Pimlico, both receiving their supply from the Thames. Not less than *ten hundred* weight of fish, *alive* and *healthy*, were taken out of the former, and a proportionably large quantity from the latter—proving the assertions concerning the water to be untrue.

† Dr. Paris, *Minutes of Evidence*, p. 46. "*Offensive* and *muddy*," yet "*use it for washing!*" The writer of the Dolphin does not relate whether he found the squeamish doctor at this cleanly operation when he "waited upon him with a specimen of the said water;" but in his Memoir he seems quite *alarmed* lest "the inhabitants of the metropolis" should emulate the *Hottentots*; for, in the fervour of his emotions, he exclaims, "Is there not a word to be said on the score of comfort and cleanliness? Is there nothing offensive to the senses in the use of this water? Has it not an inevitable tendency to change the habits of Englishmen—to lower our notions of propriety—to *reduce* us to a *filthy race?*"

asked the question, "Have you seen any bad effects of it in your practice?" his answer was—"No; my patients are supplied with *beer*, and are also very much disposed to correct the bad effects of water-drinking by the aid of *gin*!"* Another of the medical sages, who had been a member of the Anti-water Monopoly Association of 1821, stated, that the Directors of the Grand Junction Company had exhibited "a culpable disregard of the *health* and comforts of the inhabitants of London," by supplying water that was "muddy," besides enumerating other offensive qualities. Though he so confidently reprobated the water, on his opinion being requested with respect to "*the healthiness* of the Thames' water," he said that "*no individual* ought to decide that question; and the comparative *wholesomeness* of water for domestic purposes was a fit subject to be submitted for the decision of the Royal College of Physicians!"† This "*eminent*" man had also a scheme for supplying the metropolis with "pure water from Isleworth, by means of a tunnel, but whether it would cost 20,000*l*. or 40,000*l*. per mile must be determined by civil engineers." These instances are selected from a considerable mass of similar materials, and will, perhaps, be quite sufficient to enable the reader to decide on the value of such testimony with regard to the contamination of the Thames.

Among the number of persons who had "remedies to

* Dr. Somerville, physician to Chelsea Hospital, *Minutes of Evidence*, p. 52.

† Dr. Kerrison, *Ibid.* p. 45. Should this sagacious suggestion be carried into effect, what a "turmoil will it occasion in the stomachs" of the poor cooks and housemaids! For in that case they will not be able to have a comfortable cup of tea, to make a dish of gruel, or even to boil a cabbage, until the water to be employed in the process shall have received the deliberate sanction of the perspicacious and unthrifty Æsculapians!

propose," the most conspicuous was a Mr. James Mills. Having been one composing the public meeting to determine on petitions to Parliament, and on that occasion displayed his oratorical powers in depreciating the condition of the Thames, as well as the general supply of water to the metropolis, he delivered a prolixly written "Statement to the Commissioners." It may be fairly presumed that the aim of this elaborate production was to exhibit the variety of his attainments, and the superiority of his capabilities for great undertakings. Mechanics, chemistry, hydraulics, figures of rhetoric, and figures of arithmetic, with a sprinkling of Latin, were indiscriminately commixed and combined in this *luminous* composition. But no person can properly appreciate its *admirable* qualities without perusing the accomplished "engineer's" own words, as will be obvious from the following extracts.

"I consider the river Thames, at ebb tide, from Teddington Lock to its junction with salt water in its passage to the sea, as *a body* of fresh water *flowing down a regular inclined plane*, the *particles* of which *keep nearly their own position*, *similar* to *globes* of *shot* or sand, and from the counter resistance of the tide as returning on the flow, subject to the same natural regulation. Supposing this stream to be sixty miles in length, and at midway it should receive daily a large supply of an oily fluid, sufficient to fill half a mile of the stream, I apprehend we should perceive this fluid running daily with the ebb several miles below the place at which it was received, and returning with the flow several miles above, but it would not reach the sea at one end, nor Teddington Lock at the other. A similar effect, I conceive, is produced by the discharge of the drainage of the metropolis into the Thames, in its passage from Hammersmith to the river Lea." But still

further to heighten his "faint picture," he states, that "the Thames is neither more nor less than the common sewer of London, so far as receiving the contents of all the sewers;"—that it contains a "mass of filth which is in a progressive state of *increase* and offensiveness;" and *may* reach to a state of *putrescence* in time!" "*This* (says he) *is the theory which I have formed;*"* and can it be denied that his very elaborate "statement" of it displays in a very striking manner his talent for correct description and penetrating research. Though the ingenious inventor of it modestly pretended to the possession of only "a slender portion of common sense," could such a felicitous specimen of the union of *shrewd* observation with scientific and practical knowledge, otherwise than impress the Commissioners with a high opinion of its value? Hence, therefore, its accompanying their Report, to illuminate the public: and could any delineation convey a more faithful and apposite representation of our classic poet's "Father Thames," and "his silver winding way," than this masterly drawn portraiture? According to this artist, it seems that the "Thames, from Hammersmith to the river Lea," is nearly in the state of an actual puddle, consisting of almost every kind of offensive matter, which, being confined within its limited channel, is regularly impelled by the tide backwards and forwards, without any change being produced in its condition, unless for the worse! As this movement has been regularly going on for many centuries, if such be the state of the Thames, it cannot excite surprise that the poor fishes are so uncomfortable in the "necessary element" of their life; and who can wonder that, in order to avoid the annoyance of the "turbid" and "horrible mixture," they should "jump

* *Minutes of Evidence*, p. 62.

out of the river and get on to pieces of wood?" However, every person who surveys this picture, so boldly sketched and artfully coloured by the "eminent engineer," will perceive instantaneously its strict accordance with those of the "worthy author" and the "professional men of eminence." But will not observant people, who may have long resided on the banks of this noble stream, yet never could see any such effects, denominate the drawing either a clumsy caricature, or a vile daub, the production of some uninstructed and unskilful practitioner, who was alike ignorant of his materials and the use of his pencil? "Common sense" may also lead them to prefer *verity* and *facts* to fabulous relations and unauthorized assumptions, even though embodied in "pomp and prodigality of phrase." In this case, is it not palpably obvious that the *theorist's* "imagination bodies forth the form of things unknown," which, with a convenient readiness for his purposes and "views," "his pen turns to shapes, and gives a local habitation and a name?" Perhaps a slight examination will prove his theory to be founded, not on *facts*, but rather on "airy nothings;"—"mere fancy's child, and folly is its father."

The *philosophical* observer of the Thames also quoted some passages from the writings of Bergman and Fourcroy;* but had he perused more of the works of these truly eminent chemists than the two short passages which he has cited as authorities, perhaps he would have acquired so much knowledge of chemistry as might have prevented his sneer at "the process of a tea-kettle laboratory," or his making any of its useful processes the subject of his ridicule and scorn. However, the principal object of the quotations may have been to exhibit the extent of his

* *Minutes of Evidence*, p. 62.

reading on the important subject of "pure water," and to prove that his knowledge of the "mighty dead" was not inferior to that of his *learned* friend and coadjutor the author of that "little book—The Dolphin." As an apposite illustration of his ingenious "theory," the "man of science" affirmed it to be an "incontrovertible fact" that "the ullage of the Thames' water is in a *progressive* state of *increase* and *offensiveness*;" and "that it cannot possibly be otherwise from the construction of the bed of the river, which consists of a series of *excavations*, from which it is impossible the *feculence* there deposited can escape; and if this be so, it may reach a state of *putrescence* in time!"* Various and astonishing as had been many of the other *facts* detailed to the curious and inquiring Commissioners, how greatly must they have been astounded by this statement of the Thames' water "reaching a state of *putrescence* in time!" But is this acute investigator of causes, and accurate observer of effects, utterly unacquainted with the commonly known "*incontrovertible fact*," that the water of a fish-pond, however large may be its dimensions, or whatever "feculence" may be "deposited in its "excavations," never "reaches a state of *putrescence*" if a small current only of fresh water be constantly running through it? As this is a simple instance of what invariably takes place in similar cases, what must be the obvious conclusion, as to the effects produced upon the immense volume of water in the Thames, agitated by the daily motion of the tides, and by the great number of streams which are constantly flowing into it, as well as a variety of other causes which act powerfully, and some of them "operate unseen?" To realize the sagacious theorist's "extensive views" of the

* *Minutes of Evidence*, p. 66.

state of the Thames, and to give even a plausible colour to his *philosophical* statement, it would be absolutely necessary that the water in the Thames should actually become *stagnant.*

Great as the exertions of the ingenious projector of the *new scheme* for supplying the metropolis with "*pure* water," may have been to render his "theory" "clear and intelligible," perhaps those who may endeavour to reconcile some of its positions with the principles which are known to regulate the operations of nature, will find them a little obscure, if not irrational. Though he expatiates on *his* "*survey* of the bed of the river," it does not appear that he ever ascertained its form by soundings, or traversed it with a *diving bell*, on purpose to examine its "construction" so closely and minutely, as to enable him positively to aver that it "consists of a series of excavations, from which it is *impossible* the *feculence* there deposited *can escape.*"* It is evident that he presumes the "excavations" to be perpendicular, like a common well, such a circumstance being a necessary condition of his statement. However, if this were really the fact, would not his "particles keeping nearly their own position, *similar* to globes of shot or sand," when put into motion by the tide, as they rolled along his "inclined plane," soon fill his excavations to their brim, and thus make the bed of the river what he supposes it to be, "A regular inclined plane,"—with a smooth surface? But in such a case what would become of the notion broached in his statement, as to "its progressive state of increase and offensiveness, so as to reach a state of *putrescence* in time?" This illustration of his theory, clearly displays his perspicacity and judgment; but the bed of the Thames being

* *Minutes of Evidence*, p. 66.

like an "inclined plane," the particles of water "similar to globes of shot," "excavations," "feculence," and "putrescence," &c. were necessary to the perfection of his "picture," so as to render every part of it (to use the painters' phrase) in perfect keeping!

When the truly scientific observers of nature contemplate the varying appearances which result from the processes constantly going on in the great material laboratory on which they reside, they perceive that the most potent causes are incessantly, though gradually, operating to effect those changes which produce the "pure air," "pure water," as well as all the other substances that contribute to the "health," "comfort," and enjoyments of mankind. But the more sagacious surveyor of the Thames professes to have discovered serious evils in some of those operations, as well as in several of others by which art affords her aid to adapt them for very important "domestic purposes." By a peculiar combination of knowledge and ingenuity, having contrived and matured a plan far surpassing all others, which if executed would infallibly accomplish their removal, hence a desire to promote the public benefit induced him to lay it before the Commissioners. The author of the "Memoir" averred that "the inhabitants of the metropolis *are not safe* in the hands of the monopoly;" and "that the establishment of a *new Company* would be an essential benefit!"*—he also professed to have "no object in view but a public one;" but in his "*statement*" the engineer developed the *disinterested* views of both by affirming, "he had not hesitated to explain *the more extensive view* which he had taken of the subject, in contradistinction to *the desire* of Mr. Wright, of *merely* establishing *another rival* Company to the Grand Junction."†

* *Minutes of Evidence*, p. 157. † *Ibid.* p. 65.

Besides he *modestly* affirmed that "there is *no other practical remedy than that he has urged!*" though professing to have at the time a "slender portion of common sense." Perfectly assured of the incomparable superiority of his own matchless capabilities, with rapture he exclaims, "How simple! how practicable!" Hence he strenuously and confidently recommended the speedy adoption of his progeny—his precious *infallible nostrum*, doubtless with the benevolent view of obviating "the direst calamity that can befal a populous city." That the object of both was the establishing *another* Water Company, the circumstances afterwards disclosed in the evidence given to the Select Committee of the House of Commons, of which Sir Francis Burdett was the chairman, proved beyond all doubt. Though their schemes "would require *the outlay* of *a million*, the overthrow of a *grinding monopoly* of an element of life," and "the establishment of the supply of pure and wholesome water on a *sure* and *lasting* foundation, would be *cheaply* purchased at *any* price." And "if the government of the country would but become the dispensers of the blessing, *so god-like an object* would soon be accomplished." "*Simple*," "*practicable*," and "*disinterested!*" say its ingenious and skilful projectors; and who will venture to question their capabilities to accomplish "so god-like an object," or indulge the slightest doubt of their qualifications to remove all "difficulties" and obstacles, even should they happen to be mountains?*

One reason urged for the adoption of such a "plan"

* By a reference to the "Statement" of this extraordinary genius it will be perceived that his *calculations* of the effective power of steam-engines, are equally *correct* with his philosophy, chemistry, &c. A fifty-horse power is represented to pump several more thousand hogsheads than a seventy, and in less time!

was, that it would be reckoned among "the splendid and useful improvements" so desirable to be "effected in the richest, largest, and most populous city in the world," tending not only to "fix its character and elevate it in the scale of nations," but also "to remove a national disgrace." * Hence, agreeably to the hint given by the author of the Dolphin, "Why have not the Grand Junction Company *walked off* with their pipes and their engines, and abandoned the wretched speculation," † that such an union of rare talents, "pure" disinterestedness, and scientific knowledge might at once be displayed, to promote the "health and comfort," as well as to add to the magnificence of the superb capital of the British empire? But would their device to supply the metropolis with "*pure* and wholesome water," afford a supply of *purer* or *more salubrious* water than is at present supplied to the inhabitants? Would not its only effect probably be to *double*, if not *treble* the *price* which they *now pay* for their supply? And if such an addition to the cost were not a "*blessing*" to them, it might be a "*benefit*" to "eminent engineers," and "worthy authors," who formerly professed that they had "no object in view but a public one!"

Having noticed the principal "*allegations*," as they are denominated in the "Memoir," respecting the water supplied to the metropolis, let us advert to the evidence of those persons, whose practical skill united to scientific acquirements enabled them to ascertain correctly its real qualities by *actual experiments*, and who consequently may be presumed capable of affording the most satisfactory information. From documents appended to the Report of the Commissioners, it appears, that, by an ap-

* *Minutes of Evidence*, p. 154. † *Ibid.* p. 134.

propriate contrivance, *seventy-eight specimens* of the Thames and New River water were collected in bottles for the purpose of being chemically analysed. The water thus obtained from the Thames was taken not only from different parts of the river, but at various depths and states of the tide, as well as at different temperatures. *Three* specimens were also taken from what was designated the "*poisonous*" water of the London Docks; and in order that no mistake might occur, and that the properties of each specimen might be correctly noted, every one of the bottles was regularly numbered, and the place also registered whence the water it contained was procured. Hence, it must be evident, that every precaution tending to ensure accuracy and to prevent mistake was carefully adopted, so that nothing might be left to *supposition* and *conjecture.*

The Commissioners state in their Report, that "in order to ensure the subjecting of all these various specimens to the most careful and rigid examination, upon one uniform system, we put them for that purpose into the hands of Dr. Bostock, a gentleman eminently qualified for the task, by his extensive knowledge of chemistry, and his practical experience in this department of analysis." The Commissioners probably would have found it difficult to select any man, whose scientific attainments and other qualifications were better calculated to assist them in the discharge of the important duties of the office which they had undertaken; and the doctor proceeded to examine all the different specimens with the most scrupulous exactness. From the horrifying representations which had been given by the strenuous advocates of "*pure water,*" it is not unlikely that many persons would naturally expect, as the effect of Dr. Bostock's analysis, the discovery of deadly poisons and other

noxious substances in great abundance. But on the contrary, after the most careful, attentive, and scientific scrutiny of all the various specimens of this "horrible mixture" and "mass of impurity," which had been depicted as "deleterious to health and unfit for domestic purposes," he was not able to discover more on "the average than *three grains* of *solid contents*, either *dissolved* or *suspended* in *ten thousand grains* of the Thames' water, taking the average of the different specimens.* This statement by Dr. Bostock of the quality of the water supplied to the metropolis, presents a strikingly different "picture" from that painted with so much art, and in such glaring colours, by the *veracious* author of the "Dolphin," and his medical and other assistants. But greatly as Dr. Bostock's portraiture differs from the assailants of the water and the Water Companies, his representation was corroborated by the analyses of Dr. Pearson, Mr. R. Phillips, Dr. Lambe, and Mr. Gardner, whose experiments to ascertain the state of the Thames' water produced almost precisely the same results; and it is a circumstance deserving of notice, that *the very worst specimens* of the water—even those collected near to the "*polluted*," terrific, and hateful Dolphin, and the "*poisonous*" London Docks—were found to contain *not so much* as *four grains* of *extraneous matter* in the *ten thousand* employed in the experiments; and not one particle of this small quantity of matter was stated by him to be "deleterious to health!"

Some other very striking circumstances will likewise show that the "faint picture" in the "Memoir" was incorrect. Though so many assisted the artist with their colours and shading, the subsequent statements may

* *Minutes of Evidence*, p. 81.

enable any person possessing the slightest penetration, to decide whether he sketched with a pencil guided by *truth* and a proper *knowledge of facts*. From the experiments which Dr. Bostock so carefully made, he was led to conclude, "That the Thames, when free from extraneous substances, is in a state of considerable purity, containing only a moderate quantity of saline contents, and *those* of a *kind*, which cannot be *supposed* to *render* it *unfit* for *domestic purposes* or to be *injurious* to *health*."* The preceding statement was not only confirmed by the various experiments made by Dr. Pearson, but he even went further, and at the conclusion of his account he observed,—"It will be easily imaginable, that the *impregnating ingredients* of the Thames' water are as *perfectly harmless* as *any spring water* of the *purest kind* used in common life, indeed there is *probably not a spring*, with the *exception* of Malvern, and *one* or *two* more, that is so pure as the Thames' water."† If such then are the genuine conclusions from the results of actual experiments, made by skilful and scientific men, who had no interest in deceiving the public, what inference ought to be drawn as to the caricature and delusive representations of it, as exhibited in the "Dolphin" and "Memoir," as well as the strong colouring so thickly laid on by the "professional" and "scientific" men, and other persons whom the "worthy author" introduced to the notice of the Commissioners, in order to countenance his unfounded, exaggerated, or erroneous statements?

But every person who shall take the trouble to read the whole of the evidence, cannot fail to remark that, notwithstanding the confident and gloomy statements of the "*professional*" men, both medical and others, according

* *Minutes of Evidence*, p. 83. † *Ibid.* p. 97.

to their own acknowledgments when questioned, they really possessed very little *scientific* or other knowledge relating to the subject! Had the Thames' water been impregnated with a similar proportion of that dreadfully "deleterious" substance, *prussic acid*, it would not have been so "horrible a mixture" as to be deserving of the description given of it by the candid and disinterested pamphlet writer, and his accomplished and "intelligent" coadjutors. Their "Tales of Wonder" may have interested those who delight to ruminate among the strange and ludicrous fictions which emanate from a fervid imagination; though the grave and inquisitive admirers of truth and reality will, perhaps, consider such stories as were then told about gas, fish, and water, to be little better than "the currency of idiots." In every age the unthinking and credulous have been dupes of the interested representations of persons who subsisted by delusive contrivances; but in these days, the *assertions* and *opinions* of "professional" men may be freely examined; and however confidently urged, unless supported by undoubted *facts* and cogent *reasons*, they will have no weight or influence, except with the lowest credulity.

The persons who broached the new schemes, urged the advantages of competition to a commercial and industrious nation, and certainly they are strikingly obvious. In every country where a spirit of enterprise has been encouraged, it has given a strong impulse to genius, and excited to the most powerful efforts with the view of obtaining wealth or fame. This has been conspicuously the case in our own country, as its career in the discoveries of science, the perfection of the arts, and the improvements of manufactures, abundantly prove. But it is pre-eminently distinguished for the singular magnitude of its establishments, many of which have not only given scope

for the display of superior talents, but have conduced to combine public convenience and private comfort with individual pecuniary benefit. Canals, the establishments for supplying water, gas, and a variety of other great concerns, may be cited as instances; but the capital at first required to carry them into effect being large, and their eventual success doubtful, a great number of persons united to furnish the pecuniary means for realizing the purposes of the plan: thus the risk of loss was divided, and the great ends aimed at were attained.

Among the useful and magnificent concerns which originated from such a source, the Water Companies of the metropolis may be ranked as conspicuous, both for their public and private utility and convenience. Singular and important to the community as may be the advantages of these expensive and arduous undertakings, it is a remarkable fact, that every one of them has had to struggle through a series of difficulties calculated to damp the ardour, to discourage the exertions, and to produce the irretrievable ruin of an individual. For many successive years, no profit was the happy result of persevering and meritorious industry; and it has sometimes happened, that just at a period when a ray of prosperity began to beam on their labours, and which led them to anticipate the reward of laudable perseverance, their hopes have been suddenly blasted by the artifices of projectors, equally deficient in knowledge or skill, in any art but that of delusion. Indeed, how many instances have occurred in the great metropolis of Britain, that the reward to which real merit and honourable industry were entitled, has been wrested from its object by the confident pretensions of presumptuous ignorance, united with mendacious and unblushing effrontery?

In the "Memoir" it was stated, that the principle of

the act of Parliament under which the several Water Companies were instituted, was "to encourage competition; but that by an arrangement which took place between the Companies, all competition was virtually put an end to;" and a "*monopoly* of the sale of a necessary of life was to all intents and purposes established." The frequent and reproachful use of the word *monopoly* by the artful, is a presumptive proof of their being unable to select a term better adapted to their purposes; but when they apply it to many existing institutions, they ought both to define its meaning, and to show the justness of its application. Vulgar prejudice usually associates with it the idea of persons exclusively possessing the power, not only of selling, but of demanding any price they may choose for the articles in which they may deal; and it is generally presumed that such are also articles of necessity, that cannot be obtained from any other persons, and that an unreasonable price is consequently required for them. However, in many (perhaps in most) instances, do not those who employ the word either misunderstand its genuine purport, or intentionally misuse it? Does not its application to the Water Companies afford striking evidence of its abuse for the purpose of misrepresenting and reprobating their conduct? In the vocabulary of interested schemers the term "*monopoly*" seems to be synonymous with any thing which interferes with their own selfish views. Hence the Water Companies were denominated "gross monopolies;" as "confederated, and their combination bottomed on a disregard to the public welfare." Some of them were even charged with having "broken every engagement"—"sported with the comforts and health of their customers—actually *drenched* them with the noxious contents of a stagnant pool"—and "exhibited a culpable

disregard of the comforts and health of a large district of London." The same personage also asserted that one of the Water Companies (the Grand Junction) "exacted, in 1819, an increased rate, equivalent in no case to less than fifty per cent., and extending in most cases to ninety and one hundred per cent." In addition to this he sneeringly observed that "between that period and the year 1826, having done so much for the 'public good,' they began to think it but fair to do a little for themselves. Accordingly a *private* bill—so private that none of the Members for Westminster or Middlesex even knew of its existence—received the royal assent, by which they obtained the sanction of the legislature to a new table of rates, by which an addition of from fifty to three hundred per cent. may be levied."* To make his statement appear plausible, the candid and veracious writer gave the "*new* table of rates," which he stated "will make the intended increase clearer," and "the Commissioners will at once see what an enormous increase is meditated by the Company, *time and place fitting*."

It has been shown what kind of proofs were adduced to support the serious "*allegations*" respecting the qualities of Thames' water, and therefore it may not excite surprise if it should appear, that others against the Grand Junction Company display the same disregard for *veracity* in the relation of circumstances! It ought also to be particularly noticed that the *historian* was evidently acquainted with *the fact* as it *really occurred*, notwithstanding his palpable misrepresentation; for he afterwards unwittingly stated, as the reason of its having "escaped the vigilance of members and the public press," that "it went into the House of Commons as a private bill *for confirming certain articles*

* *Minutes of Evidence*, p. 140.

of agreement, &c.!"* Plausible as the author's statement may at first sight appear, and artfully as he may have coloured it, the reader will form his own judgment of the motives which could dictate it, by perusing the following account of the circumstances, as given in evidence by William Clay, esq. to the Committee of the House of Commons, of which Sir Francis Burdett was chairman, in July, 1828. He stated, that "a very general impression had been created, that the *real object* of the Bill (of 1826), under whatever title disguised, *was to procure a clause enabling them to increase their rates;* but the motive of the Company's application to Parliament was contained in an opinion of counsel, which was taken in the year 1824, by which it will appear, that from the inaccuracy with which the various acts, by which the Company derives its powers, had been framed, many points of vital importance to the Company were left in complete uncertainty. It seemed doubtful whether they had a legal title to their land at Paddington;—they were a Company by one act for fifty years, and they were a Company by another act in perpetuity;—they could accept a conveyance of land from the Regent's Canal Company, whilst they could not accept a conveyance from the Grand Junction Company; with sundry other disabilities and doubts as to the meaning of parliamentary enactments." And with respect to the clause respecting the "*New Table of Rates*," as it was designated by the author of the Dolphin, he averred that "*it was introduced by the express desire and direction of the chairman of the Committee of the House of Lords*," and, "as in the first instance, "*they did not desire its insertion, they*

* *Min. of Evid.* p. 140. Was not the writer of this statement, at that very time, *editor* of *The Parliamentary Debates*, and therefore fully aware of his account not being correct?

would have no objection to its being repealed!" If this statement be compared with that given by the veracious writer of the "Memoir," can any candid person discover a single circumstance which will bear the construction and colouring which he has given to it? If their respective semblance to truth and consistency be considered, which appears most entitled to belief?

The same accuracy of outline and truth of colouring appertained to the "faint picture" of the Grand Junction Company's unconscionable demands of increased rates from their customers. For, in contradiction to the unfounded assertions respecting them, the evidence proved that instead of their ever having "exacted an increased rate, equivalent in no case to less than *fifty* per cent., and extending in *most* instances to *ninety* and one *hundred* per cent.," the average of the increase of their rates *had never exceeded twenty-five per cent.*, and their accounts were produced as vouchers for the truth of the statement.

As such were the futile or groundless charges against the water, and the Water Companies, as well as the kind of testimony to support them, let us direct attention to the Royal Commission and the Commissioners, and examine whether their proceedings strictly corresponded with the object of their appointment. According to the commission, they were appointed "*Commissioners for inquiring into the state of the supply of water in the metropolis, including the south and Surry sides thereof;*" but though their duties were thus strictly defined, it appears that like Mr. Mills with regard to Mr. Wright, they took "a more extensive view," which included *new* "plans" and "surveys." It is evident that from some cause or other the Commissioners had conceived the idea of "*new works*," even *before* entering upon the *inquiry*; for as they *afterwards* confessed, they "hoped that the

evidence would have *prepared the way* for their *recommendation* of a *practicable* and *efficacious* plan of supplying the *whole* of the metropolis with pure and wholesome water!"*

From the statements of the Water Companies, the *daily* consumption of water by the inhabitants supplied by the Companies on the northern side of the Thames, amounted to about twenty-six millions of gallons; and that on the southern to about three millions of gallons, which, according to the number of houses, was an average of one hundred and eighty gallons for each house. Hence the Commissioners, in their Report, stated "That the *quantity* of water supplied in London and Westminster is *abundant;* and in our examinations of individuals touching the *quality* of the water, we have *in no instance* met with complaints of *deficiency* of *quantity*. We have reason to believe that the hospitals, workhouses, and other similar establishments, where an abundance of water is an essential requisite, are in all cases duly supplied; and upon the important subject of supply in case of fire, our evidence leads us to believe that of late it has always been ample, and that when not immediately procured, the fault has lain with the turncocks; for among other advantages of the reservoirs annexed to the works upon the Middlesex side of the river, is that of having at command a large head of water, by which the mains are kept full, and in many districts are under considerable pressure.—As far, therefore, as regards the description and quantity of water supplied to the Cities of London and Westminster, it appears that more than half the consumption is derived from the Thames, and that it is in such abundance as not only to supply all necessary demands upon ordinary and

* Schemes for new Water Works, &c. were proposed by several persons, and appended to their Report.

extraordinary occasions, but that a proportion is constantly suffered to run to waste, by which the cleansing of the drains of the houses and of the common sewers is effectually accomplished, all accumulations of filth obviated, and the general *health* of the metropolis promoted."

The Commissioners then proceed to state, "We next directed our attention to such facts, respecting the *quality* and *salubrity* of the water with which the inhabitants of London are supplied, as were in our judgment best calculated to enable us to form a *correct* and *unprejudiced opinion* upon this important question. Being a question, however, in which the interests of a great number of individuals and public bodies are deeply involved, and which has been the subject of acrimonious controversy, and also respecting which a variety of representations had gone forth to the public, we perceived that it would necessarily embrace a multitude of considerations of a delicate and complicated nature. We felt it to be our duty, therefore, to begin by dismissing from our minds whatever previous impressions might have been received from the reports and statements which had been circulated, and to be guided in our judgment solely by the evidence we should be enabled to obtain, in the execution of our commission."

The preceding paragraph being certainly characterized by a remarkable spirit of candour, it is much to be regretted, that entertaining such liberal feelings and just notions of their "duty," that the Report should have afforded any occasion to remark the difference between the *professions* of *impartiality*, and their actually being realized. For instance, upon what description of evidence did they assert that the "coal gas manufactories are most prominent in *polluting* the *river* by their *refuse?*" In the execution of their duty, it does not appear

that they either summoned or examined a single well-informed individual, from any of the establishments, to ascertain whether the assertions respecting the gas-works were true. The *inquiring* Commissioners relied on the testimony of persons most palpably ignorant of the subject, threw a most serious imputation upon the gas-works, and stated what was directly *contrary to the fact;* for had they really *inquired*, the evidence would have incontrovertibly proved that such a statement as theirs in the Report, could not be *correct!**

When misrepresentations so obvious and striking form a "*prominent*" feature in their Report, it may not be surprising if other circumstances contained in it should confer upon it the character of inconsistency. For instance, though the Commissioners affirm, that "from the commencement of their inquiries they have bestowed considerable attention upon this subject, and have endeavoured to obtain *accurate information* respecting it," is this conspicuous in their statement, that "it appears *proved* to us that the quality of the water within certain limits, included in what may be called the London district, has suffered a gradual *deterioration* within the last ten or twelve years? We *found* this opinion upon the well *ascertained fact* of the *disappearance* of *fish* from those parts of the river, to such an extent as to have led to the almost entire destruction of the fishermen's trade† be-

* In my *Compendium of Gas Lighting*, published in 1827, is the following statement:—"Formerly considerable difficulty attended getting rid of the lime, after it had been used for purifying the gas, on account of its offensive smell; but it is now placed in pans, under the fires that heat the retorts, so as to evaporate or destroy its noxious qualities," p. 25. This had been the practice for several previous years.

† If this had been really the fact, why were so many of that calling detected using *unlawful* nets to catch the *young fry* at this

tween Putney Bridge and Greenwich, and upon the circumstance, that the *eels* imported from Holland can now with much difficulty be kept alive in those parts of the Thames where they were formerly preserved in perfect health! We also learn, that the fishmongers in London find it impossible to preserve *live* fish for any length of time in water taken from the same district!" Upon what description of *information* were the assertions in this paragraph *founded*? Were the *facts* "well ascertained" by *diligent* and *scrupulous* inquiry conducted with acumen and judgment? A slender portion of common sense, with a very little knowledge, may probably enable any person to discern not only the futility, but the utter incredibility of its character.

It is likewise remarkable, that although the engineers of the Grand Junction and Chelsea Water Works gave positive and satisfactory evidence as to the improvements, then in progress at their respective establishments, they were not noticed in the Report; though there was an allusion to "projected alterations and improvements by *one* of the Companies." But when the Commissioners had obtained "*accurate information*" of "alterations and improvements," which were important, and had an obvious connexion with the primary object of the Royal Commission, why did they *omit* to notice them? Did the omission arise from an apprehension that the mentioning of them would interfere with the "plans and surveys" formerly alluded to; and would prove an insuperable obstacle in "*the way* for their recommendation of a *practicable* and *efficacious plan* for supplying the *whole* of the metropolis with *pure* and wholesome water?"

period? And why was not the water fatal to the *young* as well as the old fish?

After reciting in several paragraphs a variety of circumstances, which, it must be admitted, affect the *transparency* of the water, the Commissioners affirm, that "on examining such analyses of the water as had already been made, and were communicated by the Companies as well as by *several* individuals of *high authority in these matters*,* we *found them* to be *so far at variance* with each other as to prevent our drawing from them satisfactory conclusions." Nevertheless, to remove all their doubts on this head, had not they obtained the seventy-eight specimens of the water supplied, as formerly mentioned, which, "in order to ensure the subjecting of all these various specimens to the most careful and rigid examination, they put into the hands of Dr. Bostock, a gentleman eminently qualified for the task by his extensive knowledge of chemistry, and his practical experience in this department of analysis." The result of Dr. Bostock's investigation having been already given, as well as those of other practical chemists, it is not necessary to repeat them. But the statements of the Commissioners must excite no ordinary degree of surprise in the mind of every person who dispassionately and attentively reads the concurrent testimony of the *real* scientific men, who had actually ascertained the qualities of Thames' water by experiments carefully and skilfully conducted, if he compares them with the other statements in the Report. Like the *acute* and *anticipating* doctors, the Commissioners deal largely in the use of the words *may* and *will*, but "duty" would seem to indicate the propriety of drawing their inferences *solely* from "*well-ascertained facts*," as they call them, not *supposed* or *possible* cases. However, the "malaria" of fancy perhaps also affected

* If such were the case, the account of their experiments ought to have accompanied the Report with those of Dr. Bostock and others.

them, as well as the other "eminent men;" and therefore, instead of relying on *realities*, they might prefer wandering in her fantastic mazes—"The chaos of the mind." They descant upon "local evils," "contaminating causes," and observe, that "the statements which have been made respecting the *insalubrity* of the Thames' water, as supplied by the Companies, have also been considered by us; and although from *the few cases* which have been brought before us, of *disorders imputed* to this cause, we do not feel ourselves warranted to draw any *general* conclusions," &c.* Yet, notwithstanding their assertion about not feeling themselves "warranted to draw any *general* conclusions," almost immediately after they state, "that *many* of the complaints respecting the quality of the water are well founded, and that *it ought to be derived* from OTHER SOURCES than *those* now *resorted to*," &c.

In his "Memoir," the writer alluded, with apparent disrespect, to "a knot of jobbers holding their sittings in an obsure alley in London, and having no earthly object but—*profit!*—yet avowed that *men of science and engineers of eminence, are prepared to submit plans*." Though he professed to "have no object in view but a public one," yet subsequent events clearly elucidated his motives; and that, from some cause, the idea of a NEW COMPANY, "Plans and surveys," had prepossessed the minds of the Commissioners before they commenced the important *inquiry*, so as to modify all their subsequent proceedings, as well as their Report, facts rendered palpably evident. Hence, instead of illuminating the public, the purposes of "a knot of jobbers" were rather promoted by their labours, amply as they were paid to give *accurate* and useful information.†

* *Minutes of Evidence*, p. 154.

† They received 800*l*. each for their services in this affair, as stated by Sir Robert Peel!

CHAPTER XX.

Peculiar circumstances of some great Establishments. Fallacies in the Report of the Commissioners. Select Committee of House of Commons appointed; and Sir F. Burdett, Chairman. Examination of Dr. Roget. Mr. Mills' Plan, &c. for New Water Works; his remarkable Statements. Dr. Kerrison's singular detail concerning Thames' Water, &c. Facts showing purity not to be essential to salubrity. Reflections upon the manner of scrutinizing the private affairs of the Water Companies. Report of the Select Committee, and its purport. Different Schemes for supplying the Metropolis from the Colne. Description of the Grand Junction Company's Plan in 1830. Bill for executing it delayed by the interference of Sir F. Burdett, to employ Mr. Telford.

In our enterprising, industrious, and commercial nation, the advantages of competition have been extensively proved by experience. It has roused dormant genius into action, and excited to those great efforts which have conferred fame, and produced opulence. Hence have arisen many of those great establishments, whose peculiar circumstances entitle them to more than ordinary consideration for ensuring their welfare and permanence, inasmuch as they are closely interwoven with private comfort and general convenience. This is remarkably the case of water and gas works, from their operations being necessarily confined to certain districts. They have no resemblance to the occupations of shopkeepers or merchants, whose scene of action is not limited to a single town. Besides, such concerns require immense sums to be expended in buildings and machinery, which are not easily removed, like articles of trade, and must also be useless for every other purpose. The experiments attending their efforts are often costly, as well as signally

useful; but pecuniary benefit to the first proprietors is always dubious, notwithstanding their capital and exertions may have contributed to the improvement of science and the perfection of art. Nevertheless, when the point at which they aimed has been nearly attained by anxious and assiduous labour, sometimes have pretenders to genius, though mere pounds, shillings, and pence calculators, proposed to form a similar establishment, founded on erroneous statements and estimates, with the view of interfering with their welfare, and endangering their permanence, thus wresting from real merit the reward which was honourably and arduously earned.

Neither much judgment nor penetration will be necessary to decide whether the statements concerning the condition of the Thames, and the conduct of the Water Companies, were intentional exaggerations or positive fictions, broached and circulated to countenance the introduction of a scheme for *new* Water Works. Indeed, often have professions of aiming at remedying a great evil, or protecting the public from imposition, proved to be merely delusive pretexts to promote the views of individuals, whose chief object was to obtain pecuniary advantage for themselves. That such was really the case with regard to supplying water to the metropolis, will be strikingly evident from a series of facts developed in the course of the future proceedings relating to the subject.

It has been shown that the Commissioners, on the most trivial and inconsistent statements, imputed to the "coal-gas and other manufactories" the pollution of the Thames, and the destruction of the fish,* notwithstanding the very satisfactory evidence, by Dr. Bostock and others, of the

* As the sapient persons who described the condition of the Thames to be so "*poisonous*" as to kill whole cargoes of eels, as well as "dace, dabs, flounders," and even a *horse*, is it not singular

salubrity of the water. From the tenour of their Report, the conclusion is inevitable, that they relied more on the preposterous assertions of illiterate fishermen and others, than on the testimony of enlightened and scientific men. But before they ventured to make confident affirmations in a document, which was to go forth to the public by the authority of one branch of the legislature, would not it have been more accordant with their duty to collect with diligence authentic information, and also attentively and carefully to scrutinize it? Justice required this to be done, in order to realize the object of their appointment; and it might be presumed that curiosity alone would have afforded some stimulus to persons ostensibly thirsting after useful knowledge. Irrational and ludicrous stories seem, however, to have been more congenial with their taste, for they constitute a large portion of the curious matter appended to their Report, and likewise form the basis of its most "prominent" paragraphs!

When it is considered for how long a period the majority of water and gas works had previously contended with great difficulties, arising from prejudices and ignorance, as well as causes of different kinds, after expending enormous sums of money to effect an important public benefit, with scarcely any pecuniary compensation, surely these concerns ought not to be rashly and unjustly defamed. But the *inquisitive* Commissioners apparently concurred with the projectors, and cherished the idea of "*new works*" before they began their inquiry; therefore it cannot excite any surprise that they concluded their

that they did not bring forward similar testimony to prove that it killed the sailors, who take such large quantities of its water for use at sea, in preference to any other? The destruction of a few thousands of such bipeds would have highly embellished their awful picture of its deleterious effects!!!

labours with the same *enterprising* propensities, though they actually stated the supply of water to be *abundant*, and all the truly credible and scientific evidence proved its purity and wholesomeness. The subsequent recital of circumstances will elucidate this point, and clearly show the inference to be correct, that the *inquirers* and *projectors* aimed at the same object.

Soon after the Report, &c. of the Commissioners had been printed and delivered to the Members of the House of Commons, on the motion of Sir F. Burdett, a Select Committee was appointed to enter upon a similar investigation and, as is usual in such cases, the baronet became the chairman. Having designated the Water Companies as a "*mischievous and unprincipled* confederacy," (if the statement in "The Dolphin" be correct), and also, with others, at a public meeting, applied several very harsh epithets to the conduct of one Company, as well as to the qualities of the water supplied by them, it may naturally be presumed that his attention would be directed to *facts*, authorizing his use of strong vituperative expressions. When, however, the Committee assembled, the first person introduced was one of the Commissioners of Inquiry, Dr. Roget; and he was merely asked, "What were the views of the Commissioners as to the *remedy* that ought to be adopted?" "Did not they intend to recommend some *specific* plan?" "Did not they intend to recommend the *taking of levels between this and Teddington?*" "Were they not of opinion that the present state of things required a remedy?" "And that a change is almost indispensable."* To all these questions the answers were in the affirmative; but how far such "*views*," "*opinions*," and "*conclusions*" of the Commis-

* *Minutes of Evidence*, p. 7.

sioners were justified by any evidence adduced to them, "a very slender portion of common sense" may determine. If any part of the evidence tended to show that there were evils which required a remedy, the Companies also incontestably proved that they had long been earnestly and sedulously engaged in devising and executing plans to obviate complaints.

The Committee having ascertained the "views" and "opinions" of the Commissioners of Inquiry, their attention was next occupied with the identical Mr. Mills, who had boasted to the Commissioners of having taken "*a more extensive view*" than Mr. Wright, and of the infallible "practicable remedy" which he had devised. Being requested to "produce a map of the river Thames, *illustrating a plan* for the conveyance of water from Teddington to the metropolis,"* the production of this *previously prepared* map afforded him an opportunity for disclosing his *enlightened* views and *scientific* attainments to the Committee, by descanting upon "*earthy impurities*" and "*gaseous impurities,*" "*filtrations,*"† "*ulterior measures,*" and various other matters. Possibly these "words of learned length and thundering sound" were intended to *illuminate* the Committee, though they seemed rather to puzzle the chairman. However that might be, they certainly afforded amusement to some of the auditors, who were in a similar predicament with the "gazing rustics ranged around" the village schoolmaster, among whom

——— "the wonder grew,
That one small head should carry all he knew!"

besides forcibly reminding them of one character delineated in Hudibras,—

* *Minutes of Evidence*, p. 7. † *Ibid.* p. 9.

"Who knew whatever's to be known;
But—*much more than he knew*—would own!"*

Though Mr. Mills declared that his *new plan* was comprehensive and infallible, yet, when questioned whether, "if it were adhered to, the whole of the town would be supplied with water at high service?" he replied—"*Certainly not*:"—"that is *an arrangement for the Companies to make*, and *not* the *projectors* of this *new* supply of water!"† Afterwards he also made the following singular confession respecting the same point:—"*I am not engineer enough* to devise any plan by which we can convey to the pipes of *eight* different Companies water at a high level. I have no idea of the *practicability* of such a measure. Our present plan is of a very *simple* nature, which is to give to those Companies water *precisely in the situation in which they have it at present*."‡ "*The intention of the plan is, to enable each of the Companies to keep their own pipes, their own steam-engines, their command of tenants, and in fact to be, instead of* ORIGINAL SUPPLIERS *of water*, DISTRIBUTORS *of water; that they should have pure water brought to them at a certain price, and be distributors of that water to the* WHOLE *of the metropolis*."|| This scheme is evidently very comprehensive, and if carried into execution, how admirably and effectually would it obviate the evils of that "*grinding monopoly*" ascribed to the "confederated Companies," and so acrimoniously described by the *author* of "The Dolphin." Indeed, would it be possible to devise

* In this philosopher's "Statement" to the Commissioners, he affirmed the probability of the Thames becoming PUTRESCENT, and likewise that "*filtration* will *not* separate the noxious qualities of Thames' water, &c.;" yet on this occasion, he proposed to the Committee "to subject it to several *filtrations*, to cleanse it from all *earthy* and *gaseous* impurities!"—*Minutes of Evidence*, p. 9.

† *Minutes of Evidence*, p. 12. ‡ *Ibid.* p. 12. || *Ibid.* p. 8.

any plan so incomparably reasonable, modest, and disinterested, and at the same time better calculated to annihilate "a monopoly of a necessary element of life!" The eminent "*engineer*" also affirmed that the purpose of his *new plan* was "to bring to the Companies' engines *pure* water, and they may *go on as they do at present.*" Of course it must be presumed that the Companies were quite incapable of obtaining and bringing the pure water without the powerful aid of his extraordinary ingenuity. "How simple?" "How practicable!" he exclaimed; and if the acmé of simplicity and ingenuity too are not distinctly perceivable in the project, where will they ever be found? Must not those persons be simpletons indeed who cannot discover both in this luminous disclosure? What an exquisite device for promoting competition! But if the supply of water to the metropolis shall ever be confided to such *disinterested* persons, may not the public readily divine the consequences, and could they expect to have any other than pure and *cheap* water?

Allusion was made in a former chapter to the means sometimes employed to originate parliamentary proceedings, and, in corroboration of the fact, this business affords a remarkable proof. When the Commissioners met on the 10th of November, 1827, nearly four months after the date of the commission appointing them, which was the 12th July of the same year—it has been already stated that they applied to the Secretary of State, "to have the assistance of some person *conversant* with the business of *engineering*, *who is known* to them, and in whom they can place *perfect confidence*, as their secretary." Again, on the 23d of the same month, in a letter to Mr. Spring Rice, they stated that, "in consequence of the absence from London on professional duties, *ever since* the commission was issued, and the dangerous ill-

ness of Mr. Telford, it had been impossible for them to meet for the purpose of transacting business until the present month." The two facts recited above are deserving of very particular notice, from the illustration which they afterwards received from Mr. Mills's *own* testimony to the Committee of the House of Commons. To their question, "When did you begin your survey?" he replied, "I began the survey *soon after the commission was instituted!* Mr. Telford stated to me, that he was requested to undertake the survey, but his health was such that he declined it." Again: "Did the Commissioners instruct you verbally to commence this survey?" —"*I think not:* I should say it was *understood between* Mr. Telford and myself!"*

Mr. Mills likewise acknowledged to the Committee that he "commenced a survey in 1823;" and at the same time stated, "it was from *that* survey that *this plan* was *first* designed by him!"†—The same "civil engineer" also mentioned other circumstances elucidating the *origin* and *progress* of the "practicable and efficacious plan," for the recommendation of which, the inquiry of the Commissioners was probably intended to have "pre-

* *Minutes of Evidence*, p. 22.

† *Minutes of Evidence*, p. 22. Though apparently a *volunteer* in this business, he stated to the Committee, that if the Commissioners had been invested with power to pay him, he expected to be remunerated to the amount of 700*l.* for his *services!* In a paper, circulated by the author of the *Dolphin*, with the names of twenty-one *medical men* appended, to obtain *remuneration* for his *services* also, he mentions "a subscription of between 300*l.* and 400*l.* having been expended in printing and circulating his pamphlets, more than 20,000 circulars, the calling two public meetings, the *petitions* to Parliament, &c." But so far as concerns the plentiful supply of salubrious water to the metropolis, was not every plan for its improvement actually devised, and some of them in the progress of execution, before these two personages got up their *meetings* and *petitions*?

pared the way." He affirmed that he "was occupied about *four months;* all the time Mr. Telford was ill, and while he was away, he proceeded in it; but when the case was brought before Parliament, it was upon the petition only of Westminster; and *as soon* as the commission was appointed it *occurred* to him, that this could not be undertaken as a matter relating to a single Water Company; that Parliament could never listen to the complaints respecting *one* Company only, when there were *seven* Companies *equally bad;* and he did state to Mr. Telford, he thought it was a *great pity* that the whole question should not be brought before them, particularly as to the south of London; and he *employed* gentlemen to *prepare petitions*, with a view to bring the whole question before his Majesty's Government; *accordingly two* petitions from Lambeth and Southwark were sent to Lord Lansdowne, and which made the commission of a more extended nature." Being asked the question—"Then you employed yourself in *getting up* petitions *before* you *commenced* the survey?"—his answer was—"Yes?"*

Can any circumstances more effectually elucidate the "*more extensive view*" of the "civil engineer," his "*no other practicable remedy*," and the Commissioners' "practicable and efficacious plan of supplying the whole of the metropolis?" Does it not clearly "show the scheme to have been conceived *before* the inquiry had even commenced? Though *more than four months* after their appointment they inform Mr. Spring Rice, the under Secretary of State, that from the circumstances of Mr. Telford's illness and absence, it had been "*impossible* for them to meet for the purpose of transacting business;" yet, if the

* *Minutes of Evidence*, p. 22.

statement of Mr. Mills be correct, does it not appear that "business" had been transacted by at least *one* of the Commissioners; a *civil engineer* too; and is it either unfair or improper to infer that this "business" was "preparing the way" for introducing a new Company, on the plan of rendering all the established Water Companies their dependants and subservient to their purposes, possibly too at the expense of millions to the nation, and the probability of more than doubling the price heretofore paid for the water?

From the statements of Mr. Mills to the Committee, it also appeared, that "Mr. Telford had employed him much during *the last four or five years*:" "told him to go to Milford Haven to make a report on the proposed *new* landing quay;" and he "had made *surveys* of 1200 miles for the Post Office, &c. under Mr. Telford's direction." In reply to a "*separate note*" from Sir F. Burdett, Mr. Telford, likewise "begged leave to state, that he considered Mr. Mills *a very proper person* to take levels, and delineate the course of any line of watercourse which may be found necessary." Do not these circumstances very clearly show, that a *new Company* was the sole object of the "civil engineers;" and that the deputy and man of all work to Mr. Telford was the "*pioneer*" in the "plan for the *new* supply of water?" Besides, Mr. Telford having, as Commissioner, signed a report containing that striking *incongruity* with the *real* fact, the representation of the "*coal-gas manufactories polluting* the river by their *refuse*," as well as the statement, that "the water *ought* to be derived from *other sources* than those now resorted to," can it excite surprise that he should be concerned in suggesting "remedies applicable to the existing evils?" and that he should also consider Mr. Mills "a

very proper person to take levels?" Had not the latter descanted upon the "*impurities* of the Thames' water at Willis's Rooms;" and "*employed gentlemen*, as well as himself, in *getting up* petitions" on the subject? What person could be so proper to be the chief instrument in accomplishing the object of the inquiry, and in realizing the "views" of the Commissioners?

Moreover, the same person actually proposed that this great project should be undertaken by the government, at the estimated expense of about 350,000*l.*, though the amount would probably be twice or thrice that sum, as is usual in such cases, and the Companies were to be *compelled* to pay five per cent. interest for the money expended! But if such an *economical* plan should chance to be adopted, how admirably would it realize the avowed object of the most clamorous complainants, that of obtaining a supply of "*pure* and *wholesome* water at a *cheap* rate?" Would not the inevitable effect of the ingenious and *patriotic* efforts of the "*eminent*" projectors inevitably be to compel the inhabitants of the metropolis to pay more than double the price which is now charged by those who supply them? But the "*confederated* Companies" were accused of possessing a "grinding monopoly of a necessary of life," because they had the power to supply the public with water at about *one farthing* per barrel, by which they obtained a very small remuneration for their exertions, and the use of their capital; but whether the *new scheme*, if realized, would be calculated to supply it *better* or *cheaper*, may be determined by only "a slender portion of common sense."

Dr. Kerrison, who had distinguished himself by his attempts to *enlighten* the Commissioners, was also occupied in the equally laudable endeavour to illumine the Committee of the House of Commons concerning the condition of the Thames. His oral evidence to the latter

nearly accorded with his former statements in writing, and must confirm every person who had read them in their decision as to his superior qualifications to give satisfactory testimony respecting the water "leading to diseases of the viscera, enlargement of the liver, dyspeptic complaints, disturbances, and indigestion."*

The "confederated" company of authors, doctors, engineers, &c. having affirmed many strange things about the "insalubrity" produced by "the refuse of the gas works" being "emptied into the Thames," the Committee discreetly determined to profit by the opportunity which this occasion afforded them for obtaining some information on the subject. Doubtless they naturally presumed that those who professed to have so much knowledge of the "direful effects" of Thames' water, would not be found deficient when questioned. Hence, the very zealous advocate of *pure* and *cheap* water was asked, "What is the nature of the material that passes into the river from the gas works?"—and his reply was as follows: "From memory," he said, "perhaps I could hardly give it so perfectly as I can from *having made a note of it* from Professor Brande's Manual of Chemistry, whose account of the formation of gas used in lighting the streets, and of *those matters* which are *separated* and *pass away as the refuse*, will be found in the first volume of his Manual, &c." The quotation which he gave it is unnecessary to repeat; but he continued—"*my comment* upon it is this: the waste water which flows into the drains of gas works, and eventually into the Thames, consists chiefly of sulphuretted hydrogen and ammoniacal gases dissolved in the lime-water employed to separate them, and a portion of bituminous oil, or coal tar, which is *seen* to float on the surface of the

* *Minutes of Evidence*, p. 17.

liquor discharged from those sewers into which the drains from gas works empty themselves.—My *inference* is this: these *substances* are certainly *nauseous* to the *taste* and *smell*, as well as *unwholesome*, and form an unfit mixture with water for culinary purposes.* Perhaps this "*comment*" may be taken as a fair specimen of the logical acuteness, the precision, and scientific attainments exhibited by the majority of the "professional men of eminence," who rendered themselves conspicuous by their conduct about the "impurities of Thames' water." They volunteered their *opinions* and *suppositions*, but did not adduce one solitary proof as a just foundation for their inferences and conclusions! They condemned the water without assigning any satisfactory reason, and boldly *asserted* that certain substances were mixed with it, which made it *nauseous* to the *taste* and *smell* as well as *unwholesome!* But what would be the feelings of these sapient personages, if such a mode of reasoning were applied to their practice? For if a mixture that is *nauseous* to the *taste* and *smell* be consequently *unwholesome*, what ought to be the conclusion of some of their patients, as to the numerous *nauseous* mixtures recommended or administered by the squeamish and pure-water-loving doctors? Surely the veritable author of the Dolphin could never intend his "allegation" of a Water Company having "sported with the comforts and health of their customers in a way that has been rarely exceeded," should be so limited in its application as to refer solely to them!

It may be worthy of remark, that readily as the erudite doctor descanted upon the passage quoted from Mr. Brande's Manual, yet he seemed not to possess any know-

* *Minutes of Evidence*, p. 18.

ledge of their real qualities, excepting the little he had derived from Mr. Brande's book. Though he "*believed*"—was so "*sure*"—of the bad qualities of the water, nevertheless, he had "never made any analysis of it," "had not entered into the minute chemistry of it." Nay, it was evident that this *accurate* observer and *diligent* inquirer, who was so *positive* and *certain* as to all the points to which he adverted, had never even given himself the trouble to learn whether his "inferences" were justified by *facts*. But if, instead of accompanying Mr. Wright to Chelsea to look at the Thames, he had visited the gas works to which he attributed so much mischief, perhaps he might have had some of his erroneous notions corrected; for he could have *ascertained* that the *causes* to which he *ascribed* such great danger *did not really exist*, except in his own imagination, because there were no such "drains from the gas works" as he described, to "empty themselves into the sewers;" and consequently they *could not pollute the Thames!* His knowledge of the subject was obviously co-extensive with his credulity, and probably he *believed* the absurd narrative of his *scientific* friend "the author," of the "horse being actually poisoned by drinking water impregnated with the refuse of the gas works at the Horse-ferry road," and others having the same marks of verity. It is really surprising that it should not have occurred to the sagacious observer of "dead dogs, dead cats, and dead rats on the mud at the sides of the Thames," that those poor animals which he *saw* and *counted* in his various peregrinations, might likewise have come to an untimely end by precisely the same cause, as that which occasioned the death of the *horse!*

However, the value of the doctor's "comment" and "inference" will be palpably obvious from some other

circumstances which occurred during his examination. As he had expressed so positively his opinion, that certain substances which flow down the drains of gas works "form an unfit admixture with water, intended for culinary purposes;"—the sulphuret of lime formed by the union of the lime with sulphuretted hydrogen being the substance principally alluded to;—the question was put to him,—"Will not the sulphuret of lime, after a very short period, when mixed with water containing atmospheric air, be decomposed and precipitated?"*—His answer was, "Probably it will up to a certain point; but you have it enveloped with some oil and bituminous matters from coal and *ammoniacal gas*, and *I am not prepared* to say what decomposition *may* take place between the liquid refuse of gas works flowing into a channel, and from that channel into the Thames."† As he had stated in answer to another question, that "he should expect that sulphuret of lime in the filtering agent would be enveloped;" he was asked, "if chemical analysis will determine sulphuret of lime, dissolved in water, which has passed through a filter?" His reply was, "I have never tried it!" Again—"If there is any sulphuret of lime dissolved in the water, is not that a substance as easily discovered as any substance in chemistry?"—"*I cannot reply to that question !!*"—"Do you not think that a chemist like Dr. Bostock, if a sulphuret of any kind, or if sulphuretted hydrogen had been dissolved in the water, would have been competent to discover it?"—"Assuredly I do!"—"When therefore you find in the published analysis of Dr. Bostock, that there is *no mention* of a *sulphuret*, or of *sulphuretted hydrogen* contained in

* *Minutes of Evidence*, p. 19. † *Ibid.* p. 19.

filtered Thames' water, would you not think it reasonable to infer, that neither of those substances existed in it?"— The answer to this pointed and pithy question is deserving of particular notice; and was as follows: "I *believe* that my *objection* has *not gone* so *much* to the *water* filtered, as to the *refuse matter evaporated* by the influence of the sun and air *after* the *water* has passed away!!! * What must be the "inference" respecting the qualifications of this person, who had formerly talked of referring to the "*Royal College*" the consideration of the injurious qualities of the Thames' water, and its producing "diseases of the viscera, dyspeptic complaints, &c. &c." when he thus affirmed that they arose from "the refuse *matter evaporated* by the sun and air *after the water* had *passed* away?" But this *erudite*, *sagacious*, and *scientific* personage entertained the Committee with various other specimens of such instructive "matter," about "insalubrity," "nauseous odour," "residue of gas works," "aggregate of foulness," &c. so that every one who is in the least acquainted with chemistry, and the true state of the Thames, will not be at any loss to appreciate the acumen and knowledge displayed by one of the most officious of the alarmists on this occasion at "the western part of the metropolis."

However perplexing some of the questions had been, the doctor boldly persevered in his career, and maintained that even "filtration is not a sufficient remedy" for the impurities contained in the Thames' water! Though he affirmed that he "cannot go fully into the question of Dr. M'Culloch, on Malaria," yet he "*believed* that the accumulation of the *refuse*, or *whatever* it *may* be, of animal matters or vegetable matters arrested

* *Minutes of Evidence*, p. 20.

by the sand, or whatever else, when exposed to the action of the sun and air, would exhale an unwholesome vapour, —was *sure* that there must be an *unwholesome impregnation* of the air! For when the mud from the bottom of the canal in St. James's Park was spread out, a practitioner of Queen Street had *four cases* which he *actually traced* to have arisen from the inhalation of that vapour; and one of those cases was seen by Dr. Warren. Besides, Dr. Paris *told* him, that at the time the mud was in St. James's Park, he had a case of remittent fever, that he was *sure* was produced by the *effluvia* from that source!"* The professional man had been *told* these things, and therefore *he believed* them: and with such tales, erroneously denominated *facts*, were the time and attention of the Committee occupied, or rather wasted; for could such idle chit-chat elucidate any of the important points which they were appointed to investigate?

Having, with a pompous display of the technical verbiage of his profession, depicted the consequences of using Thames' water, surely it was reasonable to expect, that where so much *knowledge* of *cause* and *effect* was possessed, the picture drawn by the skilful painter will be true to its objects, and a faithful delineation of such as had really been seen, and not those of "fancy bred." The artist's own account, however, and "common sense" will enable any person to form a correct decision without the aid of the Royal College, for in answer to another question he replied,—"*It will not be easy to state any particular case of disease brought on by it*; but he *believed* that a *general insalubrity* must exist in water!!!"† If the basis of philosophy be *facts*, how

* *Minutes of Evidence*, p. 18. † *Ibid.*, p. 17.

curious is the logic of this philosopher? And what must necessarily be the conclusion as to the statements, and perspicacity of this professional sage, whose hostility to the Thames' water, and the Water Companies, had been more persevering and acrimonious than that of any other person, excepting the *disinterested* author of the "Dolphin?"

The above detail shows that medical men could "*think*," "*believe*," "be of *opinion*," and speak "*positively;*" though they did not adduce *one fact*, or assign *a single scientific reason* either for their *belief* or *opinion* But can any sane and thinking person deem the mere *belief*, *assertion* or *opinion* of such physicians, to be equivalent to well-ascertained facts like those resulting from the experiments of Doctors Bostock, Pearson, and others? It is obvious that the "men of science," whose efforts had been so very zealous in creating *alarm* about the "deleterious" qualities of Thames' water, were not *experimental philosophers*, but persons whose knowledge consisted in *conjectures* and *inferences* having no adequate basis for their support, and in some cases being completely discountenanced both by fact and probability. When these persons affirmed they *believed* and were *sure* that certain causes actually produced the effects which they ascribed to their agency, the observant and reflecting portion of the public naturally expected some *reasons* for such *belief* and *assurance;* great however as was their facility at "comment," "inference," some of their comments, and inferences, were palpably erroneous and absurd, because even the causes to which they so positively attributed the effects had really no existence!

If substances really deleterious in a concentrated state, sometimes find their way into the Thames, and other

rivers, the quantity is generally so small, in proportion to the great volume of water, that probably its wide diffusion in the fluid renders it quite harmless; and as an illustration of this some very striking facts may be detailed.

Various medicines usually prescribed to remove serious diseases, consist of ingredients that are actually poisonous, and would certainly produce injurious effects upon the human frame, if administered in large portions, or without being plentifully diluted with water. The common atmospheric air also affords another appositely analogous instance of the kind; for although it be composed of different materials, of which the largest proportion is very *deleterious*, yet when mixed with about one-fifth part of its quantity of oxygen, the compound becomes not only salubrious, but animated beings constantly inhale it as an indispensable element of life!* This circumstance is known by all persons who are cognizant of the constituent elements of the air which they breathe, hence it may not be unreasonable to presume that the properties of water, may rather be improved, than deteriorated, by its mixture with a very small portion of extraneous matter; and the analyses of the water of the river Thames, even in its most feculent parts and condition, have evinced that the proportion of other substances mixed with it, amounted only to about *one grain* in *three thousand!*

The benevolent Creator having furnished men with organs to separate the salutary from the noxious parts of the air "in which they move and live," is it not proba-

* To the instances recited above may be added, that substance which gives the sparkling appearance and grateful flavour to various kinds of wine and artificial waters, commonly taken as beverages. It is precisely the same as that causing death in mines, and the vats in breweries; yet does any person ever feel alarm at drinking champagne, fine bottled ale, or the preparations with *carbonic acid gas, &c.*—usually called soda water?

ble that they likewise possess those which are similarly adapted to water in its usual state, so as not only to prevent its being hurtful, but actually to render it conducive to health? Notwithstanding the confident asseverations of the medical practitioners, they did not adduce a single convincing proof of its being productive of disease; and experiments have satisfactorily proved, that if human beings were constrained to breathe pure oxygen (*vital* air) alone, its stimulating effects would inevitably abridge the period of their existence. Thus it must be evident, that whatever notions may be entertained and broached by partial or unscientific observers, in some of the most important cases affecting the sustenance and comfort of mankind, such *purity* as some squeamish persons desire, does not constitute the most prominent quality. How admirably indeed has the great Author of Nature provided for the purposes of human life, by an arrangement of operations, which reciprocally aid each other, to render both *air* and *water* salubrious; even though the fastidious may be disposed to complain, that contingent circumstances occasionally interpose to circumscribe the full enjoyment of their benefits!

Though some assertions in the Report of the Commissioners apparently hinted at the inefficiency of the Water Works then supplying the metropolis, yet a series of facts were detailed in the evidence, showing that the exertions of the different establishments entitled them to commendation instead of censure and defamation. Satisfactory as had been their previous testimony, the engineers and other officers belonging to several of the Water Companies were examined by the Select Committee, but principally with respect to their capitals, incomes, and expenditure, and an account of these every one of them was required to make a return. However, the

policy, justice, or propriety of even a Select Committee of the House of Commons scrutinizing their affairs precisely in the way which was then pursued, may perhaps be questioned, and also deserving of a few remarks. It does not appear that any of them had made unconscionable demands on their customers;—that their directors and managers had in any way misconducted themselves, so as to justify their being summoned to expose and explain their concerns to any tribunal. They were legalized partnerships, consisting of individuals who had united, like others, to promote their own private interests by effecting what has proved to be a great public benefit. Was their conduct reprehensible in so doing? And if it was not, why ought their affairs to be subjected to public examination and exposure, any more than those of a nobleman, a private gentleman, or a merchant? The former are at liberty to exact any rent they can obtain from their tenants, for lands and dwellings; and what good reason can be assigned that a Water Company shall not receive more than a certain small per-centage upon the amount of their capital, as a remuneration for their useful enterprize and arduous exertions? And why should they be compelled to develop all the details of their concerns, because a few sordid schemers, speculating on the advantages to be derived from the information, shall be prompted by the lowest motives to desire it? The increase of their income may prove that the number of their tenants has greatly increased; but perhaps their expenditure may have proportionably increased, so that their profits may not be relatively greater than at any former period, but they have never been unreasonably large, and often none at all for years together. When however a little more profit than usual rewarded their labours, artful schemers, actuated by the most sordid views, project the plan of a *New Company* to become their *rival*, and for

the purpose of introducing it to public notice, designate them "The Monopoly!" and vociferate "The Grinding Monopoly must be destroyed!"

It will be evident that the proceedings of the Select Committee were characterized by the same striking partiality for "*new works*," as those of the Commissioners; and circumstances afterwards transpired, proving that the management of the inquiry was in some degree under the guidance of the same individual, who furnished on *the first day of their meeting*, his *previously prepared* "map of the River Thames, illustrating a plan for the conveyance of water from Teddington to the metropolis," being also the projector of *New Water Works* for supplying the whole of the metropolis!* Hence their Report accorded with his views; and after reciting from that made by the Commissioners, several of its paragraphs which were least supported by credible evidence—or rather unauthorized by it—they urged that "Mr. Telford be instructed to proceed to the making *such surveys as he shall think necessary*, in order to enable him to recommend a

* The writer of this has often occupied himself in attending the Committees of the House of Commons, in pursuit of what has constituted for a long period a "primary element of his life"—*useful knowledge*. Though sometimes disappointed in the object of his pursuit, he has often been amazed, and certainly was so on this occasion by the evidence and conduct of Mr. M., who seemed very self-complacently to set himself up as a kind of *prompter* to the chairman and others. When one of the witnesses was giving his testimony as to the clearness and purity of the water at Hammersmith, he audibly (and it was thought rudely) interrupted him, by referring to the gas works at Brentford: on which an honourable member of the Committee (Mr. Holmes), in a stern manner observed, "It is a well-known fact that the gas works evaporate all their residuum, and therefore it cannot contaminate the water."—*Minutes of Evidence*, p. 12.—The manner in which all the engineers of the Water Companies gave their evidence, was marked by a degree of modesty that formed a striking contrast to the conduct of others.

practicable and efficacious plan of supplying *the whole of the metropolis* with water!"* After noticing some observations in the Report of 1821, some invidious remarks follow on the inequality of the rates, and the power of the companies "to charge as they shall think fit;" and then proposed "the repeal of the obnoxious clause in the Grand Junction Company's Act of 1826." To this brief document was also appended a *tabular statement* of the income and expenditure of the Water Companies from the year 1820 to 1827; the difference being headed —"*nett profit*," without making any allowance for interest on the large sum, which several of them had expended in improvements during those seven years!—The omission of this important fact was calculated to convey an erroneous notion of their prosperity, and some subsequent transactions very clearly exposed the motives for this glaring and culpable fallacy.

At different periods, schemes have been proposed for supplying London from the River Colne;—one appearing in 1719, at the time of the South Sea bubble;—another in 1766, a third in 1767, and one in 1789. The latter was tendered to the Chelsea Company, who de-

* The Report has the date July 19, 1828; and about one week prior to its being made, Sir F. Burdett produced to the Committee a letter from Mr. Telford, which was an answer to a private one from himself, and stated, "I consider Mr. Mills as a very proper person to take levels, and delineate the course of any line of water-course, which may be found necessary."—*Minutes of Evidence*, p. 36.—In the evidence relating to the same subject, recently published by order of the House of Commons, Aug. 7, 1834, the Baronet is represented to use the following words:—"I considered Mr. Telford's *name* was the main thing; but my reliance was always on Mr. Mills!"—*Minutes of Evidence*, p. 56.—Is not there ample reason to surmise that the latter lent the honourable Baronet "*a helping hand*" to draw up the Report *recommending*

clined it, although its contriver represented that the cost of effecting it would be comparatively trivial. The same project was offered to Mr. Nash, the architect, in 1813, whilst he was making arrangements for beginning the Regent's Park, and Regent Street. In 1821, it was urged upon Sir Francis Burdett; and in 1828, was also proposed to the Commissioners for inquiring into the state of the supply of water.* After having thus wandered from one party to another, unhonoured by a patron, its erratic career terminated in its adoption by the Directors of the Grand Junction Water Company.

The first intimation which the Proprietors of the Grand Junction Water Works received of their Directors embracing and nurturing this scheme, was at a general meeting, held on the 17th of November, 1830, when they were summoned to consider a plan for improving the Company's supply. Great, however, was the astonishment of many of them, when at the meeting they were apprised of an entirely new speculation being contemplated, consisting of a canal to convey water to London from the river Colne, at the estimated cost of 120,000*l.* for about thirteen miles.

On the 16th of February, 1831, the Directors called another meeting of the Proprietors to inspect and consider the draft of a bill, to enable the Company to adopt and accomplish a much larger scheme, comprising the extensive object of *supplying the whole of the metropolis*, having nearly 190,000 tenants, and requiring daily 4,500,000 cubic feet of water, although their own concern, at that period, had only 7700 tenants, requiring merely about 500,000 cubic feet! Such a proposition so astounded and alarmed many of the proprietors, that they left the assembly, and declined to commit themselves

* *Minutes of Evidence*, p. 97.

in a project which was totally inconsistent with the original object of the Company, as well as incommensurate with their pecuniary means for its accomplishment.

Notwithstanding the opposition of the proprietors, the Directors persevered, and actually attempted to realize their views, by introducing a Bill into the House of Commons for the purpose, at a much greater cost than had been first stated,—the estimate being increased from 120,000*l.* to 200,000*l.* The scheme propounded to Parliament comprised the whole of Middlesex, Surrey, a part of Buckinghamshire, and also the purchasing, holding, and letting of five copper and corn mills; deepening and embanking many miles of the river Colne, to its entrance into the Thames near Staines; besides involving the contingent probability of having to make a provision for supplying the necessary water for the five locks between Staines and Teddington, during dry periods, when the quantity required would be equivalent to their daily operations for a great number of barges!

The proposed canal was to have a width of twenty-seven feet, by a depth of four feet six inches, with two foot-paths, each six feet wide. Its intended course was to be across twenty-six rivers, streams, and sewers, thirty-one public roads, lanes, and foot-paths, by means of aqueducts, bridges, drains, and tunnels. One of the aqueducts was estimated to extend three times the length of Blackfriars Bridge, having likewise nearly the same height and width. Exclusive of the open part of the canal, there were to be two tunnels, each 1000 feet long, and likewise five reservoirs. Its accomplishment required from 200 to 300 acres of land, which was consequently to be cut through, or embanked and fenced; besides the many difficulties to obtain the possession of the land, from its being in sixteen parishes, having also

208 owners and 139 occupiers, as well as requiring the authority of commissioners of roads and sewers. From this outline of the plan, its probable cost cannot be readily estimated; but as the expense of making the Grand Surrey and Croydon Canal, of about the same length, was 18,000*l.* per mile; and moreover, as the intended aqueduct was to be more than twice the length of Waterloo Bridge, which actually cost 1,060,000*l.*, some conception may be formed of the almost incalculable expense of executing a scheme of such magnitude. If any plan of a similar kind be adopted and realized, what must necessarily be the rate paid for water, if the proprietors of the works are to be indemnified from loss?

In April, 1831, the Bill for executing the above project was referred to a Committee of the House of Commons, when Sir Francis Burdett proposed to delay the consideration of it, till *he had obtained a copy of an order from the Secretary of State, to employ Mr. Telford to make a survey, with a view to a better supply of water to the metropolis.* The proceedings were therefore suspended, and the motives of the *honourable baronet* for making this proposition have received a very striking elucidation from circumstances since disclosed, in documents published by different orders of the House of Commons.

CHAPTER XXI.

The object of some projectors of New Water Works for the Metropolis, to introduce a costly scheme at the national expense, by defaming existing establishments. Fallacy of the Report of the Select Committee of the House of Commons in 1828. Proposed improvements by the Grand Junction and West Middlesex Companies; purchase by the latter of a large estate at Barnes Elms, to construct Reservoirs, &c. The Correspondence of Sir F. Burdett with Sir Robert Peel, about employing Mr. Telford; his Survey and Report. Outline of his Plans, and their reference to a Select Committee of the House of Commons. Remarkable declarations of Sir F. Burdett and Mr. James Mills. Examination of Messrs. Telford, Mills, and others. Remarks on their Plans and Statements, by Messrs. Anderson, Clarke, Mylne, Simpson, Wicksteed, &c. Mr. Marsland's Filter at Stockport, &c. Mr. Martin's Proposal for an Aqueduct with a Rail-road upon it. Scheme for supplying the Metropolis by means of large Wells, and their probable inefficiency. Concluding Reflections.

The two preceding chapters contain a faithful recital of facts derived from authentic public documents, and every person who calmly and attentively peruses them will not only perceive the partiality of the evidence and reports, but probably conclude that their chief purpose was to give colouring and plausibility to the introduction of an expensive scheme of Water Works, by attempting to fix odium on the existing establishments. Statements marked by verity seemed to have little regard, whilst those of a contrary character formed the basis of most unjust imputations upon the Water Companies. Though not a single instance was proved of defect, either in the *quantity* or *quality* of the water supplied by the New River, West Middlesex, and some other Companies, nevertheless their meritorious exertions to serve and satisfy the public re-

ceived a share of the vituperation. Hence property to the amount of millions,—much of it consisting of the hard earnings and careful savings of many an industrious tradesman, who confided in its security to solace his old age,—was deteriorated in value, or placed in jeopardy, by the sordid efforts of a few speculating individuals. But how often have the projectors of "new works" aimed merely at their own personal advantage, deeming every other consideration to be "trifles, light as air."

That the water which had usually been supplied to the metropolis was *wholesome*, the general health of the inhabitants had incontrovertibly proved; and even persons designated "eminent medical men," who had been most vociferous in decrying the water as "deleterious," and "likely to produce some fatal epidemic," did not adduce one satisfactory reason for their confident assertions, besides acknowledging their inability to cite "any particular facts of disease brought on by it!" Indeed, the tenour of the transactions in this affair demonstrated, that the sole object of the principal actors was to establish, under their own direction, New Water Works, at an enormous cost to the nation; but, palpable as was the partiality in selecting the evidence, can any disinterested person discover the slightest grounds for the Committee to recommend the employment of Mr. Telford, at the public expense?

Unauthorized and delusive as were some of the statements in the Report of the Commissioners, that of the Select Committee was not less characterized by fallacy, of which the following is a striking instance:—After referring to "the rates of 1821, which included the increase of 25 per cent. upon the rental of 1810, as sufficient to remunerate the various companies at that period;" the Report proceeds to state,—"but an inspection of their

returns shows, that a gradual increase has taken place, amounting to no less than 44,000*l.* per annum, to those Companies who derive their supplies from the north side of the river Thames."* Though it is a fact that no addition had been made to the charge for water, yet the purport of the paragraph immediately succeeding the above was obviously intended to convey the idea, that the large sum mentioned arose from an increase of their rates, and also consisted of "*nett profit,*" as it is artfully, but erroneously, denominated, in the tabular view of their respective incomes appended to the Report. However, the identical returns from which this delusive representation was made, at the same time developed the fact of about 40,000 houses having been erected in their district, during the period referred to. This was the principal cause of the increased amount of income; besides the expense incurred in pipes, with their appendages, and other incidents to supply them, would of course be proportionably large, so that the sum stated could not be "*nett profit.*" Whether such fallacies were really intentional, the relation of a few circumstances will enable the reader to decide.

The evidence adduced to the Commissioners proved that the different establishments which supplied the metropolis had long been engaged in devising means to furnish it in a clear and salubrious state. Two years prior to the time when the most virulent abuse was bestowed upon the Grand Junction Company for neglect and inattention, they had commenced, and even at that period were actually occupied in effecting, great improvements in their works, at an estimated cost of 50,000*l.* This Company also contemplated deriving their supply of water from a place about

* *Report*, July 19, 1828, p. 5.

400 yards from Richmond Bridge, according to a plan mentioned in a letter, dated June 10, 1828, to Mr. (now Sir Robert) Peel, then Secretary of State. Besides, in January, 1829, with a view to realize the project, they applied for permission to lay pipes through Kew Gardens, but it was refused, although it would not have occasioned the slightest inconvenience, or interfered with their privacy.

The attention of the West Middlesex Company had likewise been fixed on the same object, previous to the appointment of the Select Committee; for, early in June 1828, they had really purchased a large estate at Barnes Elms, nine miles above Westminster Bridge, and extending along the side of the Thames for about two miles and a half. Its site was peculiarly eligible for their purpose, besides affording the most ample space for constructing spacious reservoirs to collect a large mass of water, filtering it, or forming any other works that might be required. Moreover, the Chelsea Company were then engaged in effecting very important and expensive improvements and additions to their works; other establishments were also similarly exerting themselves to obviate every cause of complaint; for regard to their own interests naturally dictated that they should endeavour to afford the most complete satisfaction. Extraordinary and costly, however, as were these efforts to merit approbation, the facts which have been related show that some projectors of new schemes attempted to render them odious in the public estimation; but the following extracts from correspondence printed by order of the House of Commons,* will clearly elucidate their motives.

Abundant as was the supply of water, and earnestly

* March 15th, 1830; May 4th, 1830; and Feb. 27th, 1832.

and assiduously as the Companies were endeavouring to improve its qualities, nevertheless Sir Francis Burdett seemed determined to have "new works." Hence, in February 1829, he addressed a letter to Sir Robert Peel, urging him to employ Mr. Telford, and also to "allow 3000*l.* for a survey," from the public Treasury. To this an answer was returned, stating, that "such a survey would probably cost from 3000*l.* to 5000*l.*, and the Treasury did not feel justified in directing it to be done, as Mr. Telford would not bind himself, that it should not exceed the latter sum." After rather more than two months had elapsed, Sir F. Burdett again urged "the sanction of the Treasury to employ Mr. Telford at an expense, not exceeding 2000*l.*;" and concluded by affirming that "plenty of persons were ready to advance money for *any plan sanctioned by Government.*" To this Sir Robert Peel concisely rejoined, that "on public grounds the Government ought not to be subject to any expense."

Reiterated as had been the refusals of the Government to consent to Sir F. Burdett's propositions, nevertheless, on June 2, 1829, he renewed his application for authority to employ Mr. Telford, adding on this occasion, that "he will *himself* undertake to get a survey made for 1000*l.*, and also *make good any excess*, for all he wants is the sanction of the Government." As Sir Robert Peel probably became desirous of terminating these entreaties, he addressed a letter to the Directors of the different Water Companies, proposing that "a competent engineer should be employed to make the necessary surveys, and to report whether a sufficient quantity of water, for the use of the metropolis, can be taken either from the Thames above Richmond, or from the River Colne, and that the expense of making such surveys and estimates, shall be borne

by the Companies." To this proposal they unanimously objected, assigning as the reasons for it, their own zealous efforts, and having already *competent* engineers employed by themselves, who were quite able to effect any improvements required by the "utmost wishes of the public."

Although Sir F. Burdett had previously received no encouragement, yet after another interval of about six months, Dec. 2, 1829, he resumed his attempts to obtain an order from the Treasury to employ Mr. Telford; but Sir Robert Peel resolutely declined acceding to his solicitation, stating it to be his intention not to interfere with the Companies, who were "labouring at considerable expense to improve the quality of the water supplied."

In the following month, Jan. 8, 1830, Sir F. Burdett addressed a letter to Sir Robert Peel, to apprise him that "he had seen a section of the Thames from Teddington to London Bridge, which demonstrated the impossibility of improving the supply as taken by the present Companies, without going to other sources." He also stated that "*application had been made to great capitalists*, who replied, that they could not undertake making surveys in the face of eight Acts of Parliament." To this Sir Robert Peel returned an answer, remarking on the impropriety of the Government employing the public money for realizing Sir F. Burdett's object, and descanted on the difficulties attendant on his views; at the same time he mentioned his having received "*the draft of a Bill, with a printed letter appended*, stating that *an individual engineer* had made a survey for a line of aqueduct, &c., but not being acquainted with the engineer, he was unable to form any judgment of *the value of his opinion*; and if there were a reasonable prospect of the plan being *a feasible and profitable speculation*, it would be entered into without the interference of Government; and if it were

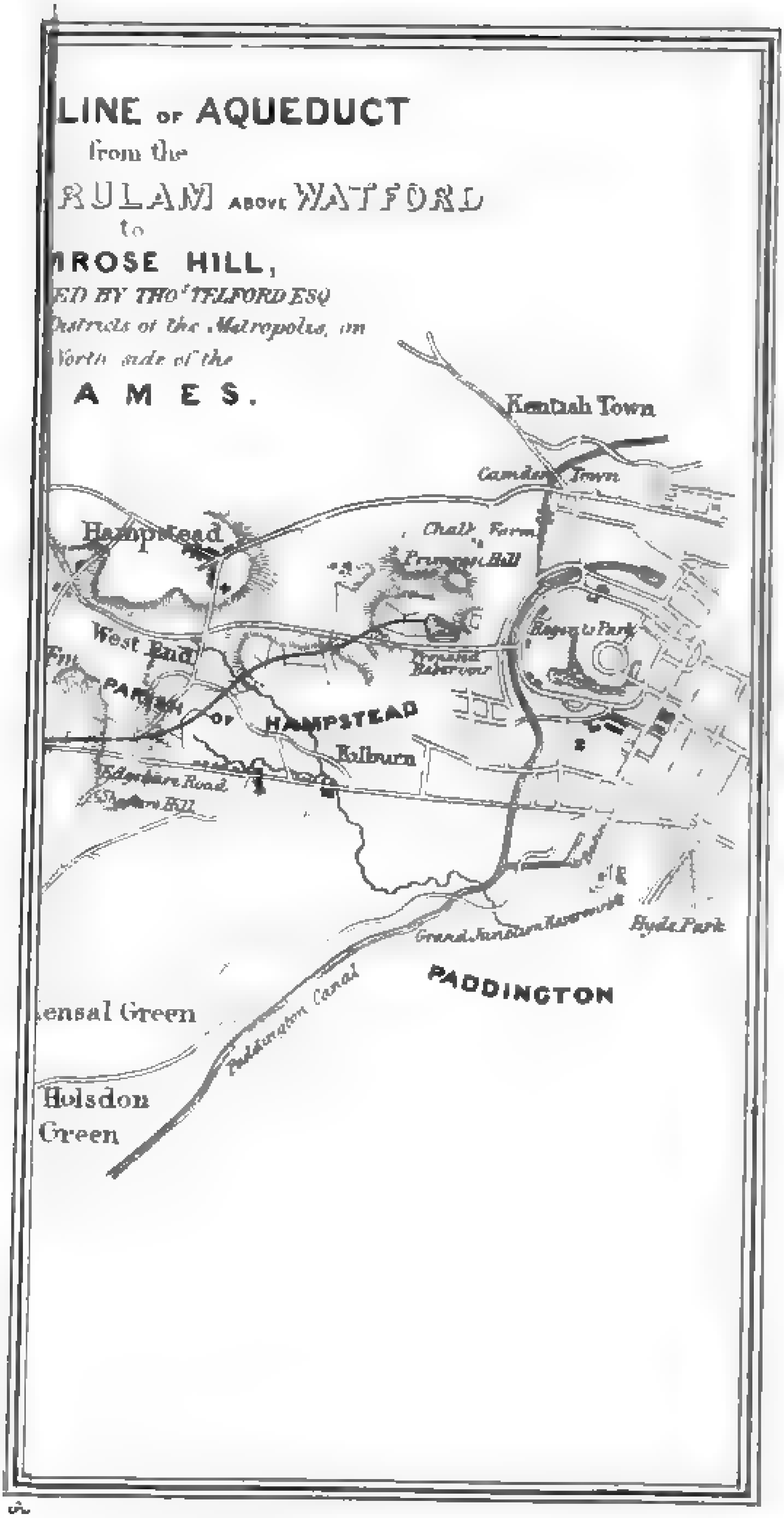
not, *it ought not to be encouraged.*"* Judicious and proper as was this reply, it did not prevent Sir F. Burdett from again writing to Sir Robert Peel, urging a compliance with his request, and likewise reflecting upon the conduct of the Water Companies; but the latter remained firm in his decision to avoid employing Mr. Telford at the public expense.

Though foiled in all his former attempts, yet Sir F. Burdett did not abandon his object; but the persons constituting the government being changed, he ventured, in January 1831, to write to Lord Althorp, then become Chancellor of the Exchequer, requesting a Treasury order, to employ Mr. Telford to make a Survey, Report, &c., at the same time averring, "he thinks this matter of such great importance, that he *undertakes to guarantee the Treasury against any expense which may attend it.*" This apparently patriotic offer induced the new ministers to furnish the required order on the 29th of January, 1831, with a copy of the Treasury minute to be sent to Mr. Telford, "for his information, and to desire that he will make his Report, as proposed by Sir F. Burdett,—(if he is willing to do so,)—*on the distinct understanding that he is to bring no charge against Government for this service.*" This clear and explicit communication shows, that as far as the survey, &c. was concerned, Sir F. Burdett's desires had been complied with on his own conditions; and the public documents affording this information, also show the nature of his conduct after the Treasury order was obtained.

* Are not there very good grounds for presuming that the "*Section of the Thames,*" as well as the "*Draft of the Bill,*" and "*anonymous letter,*" were the productions of the "individual engineer," who has made himself so prominent by his great pretensions and palpable absurdities?

Whether Mr. Telford's shrewdness led him to doubt of the validity of *the guarantee*, was known only by himself; but he returned an answer declining to engage in the work. However, after the lapse of about two months (on March 21, 1831), he consented to undertake it; and wrote to the Treasury a letter, asking the question—"Am I to understand that it is *by Government*, and *not by any individual*, that I am employed?" In the reply it was stated that he was to "*consider himself employed by Government.*" During the subsequent three months six letters, at different periods, were addressed to Sir F. Burdett, to arrange with him the mode of remunerating Mr. Telford; nevertheless on this *important* point, the *honourable* baronet refrained from giving one word in reply! On June 22, however, when the copy of a Report concerning a scheme of the Grand Junction Company was transmitted to him by the Secretary to the Treasury, he again became their correspondent; but instead of noticing the letters previously addressed to him, to remind him of his promise to indemnify government, he indulged in a long strain of invectives against the Water Companies, evading altogether the subject of his engagement *to pay the expense* of Mr. Telford's survey, which had been so pertinaciously urged upon the Treasury by himself!

On the 5th of July a second minute of the Treasury was sent to the baronet relating to the survey, but he deferred replying till the 28th of August, when he wrote to Lord Althorp repeating his censures of the Water Companies, and descanted on the increase of income by the New River Company since 1820; omitting, however, to notice *the great increase of buildings*, or the expenditure of nearly 200,000*l.* in the *extension of their pipes, &c.* to effect the supply to the increased population! Such


LINE OF AQUEDUCT
from the
RULAM ABOVE WATFORD
to
MROSE HILL,
ED BY THO^s TELFORD ESQ
Districts of the Metropolis, on
North side of the
AMES.
Kentish Town
Camden Town
Chalk Farm
Primrose Hill
Hampstead
West End
PARISH OF HAMPSTEAD
Proposed Reservoir
Regent's Park
Kilburn
Edgeware Road
Shoot up Hill
Grand Junction Reservoir
Hyde Park
PADDINGTON
Paddington Canal
Kensal Green
Holsdon Green

too was his regard for candour and justice on this occasion, that not one syllable occurred concerning his *guarantee*, although it had been so often applied for by the Secretary to the Treasury!

In February, 1834, Mr. Telford having completed his Survey and Report, delivered them to the Lords of the Treasury, accompanied with three plans, and on the 26th of March they were ordered to be printed by the House of Commons. The object of one of the plans was to obtain water from the river Verulam, two miles above Watford, being about sixteen miles distant from London. For conveying it to the metropolis, he proposed to construct a covered aqueduct, having a double water-course, with a foot-path between them to a capacious reservoir formed on Primrose Hill, at the height of 146 feet above high water in the Thames. The estimated cost of these works amounted to 785,965*l.* 11*s.* 6*d.*, and large as the sum may appear, they were limited merely to affording a supply to the West Middlesex, the Grand Junction, and Chelsea Companies,* which should respectively receive it by large iron main pipes, connecting their respective establishments with the reservoir.

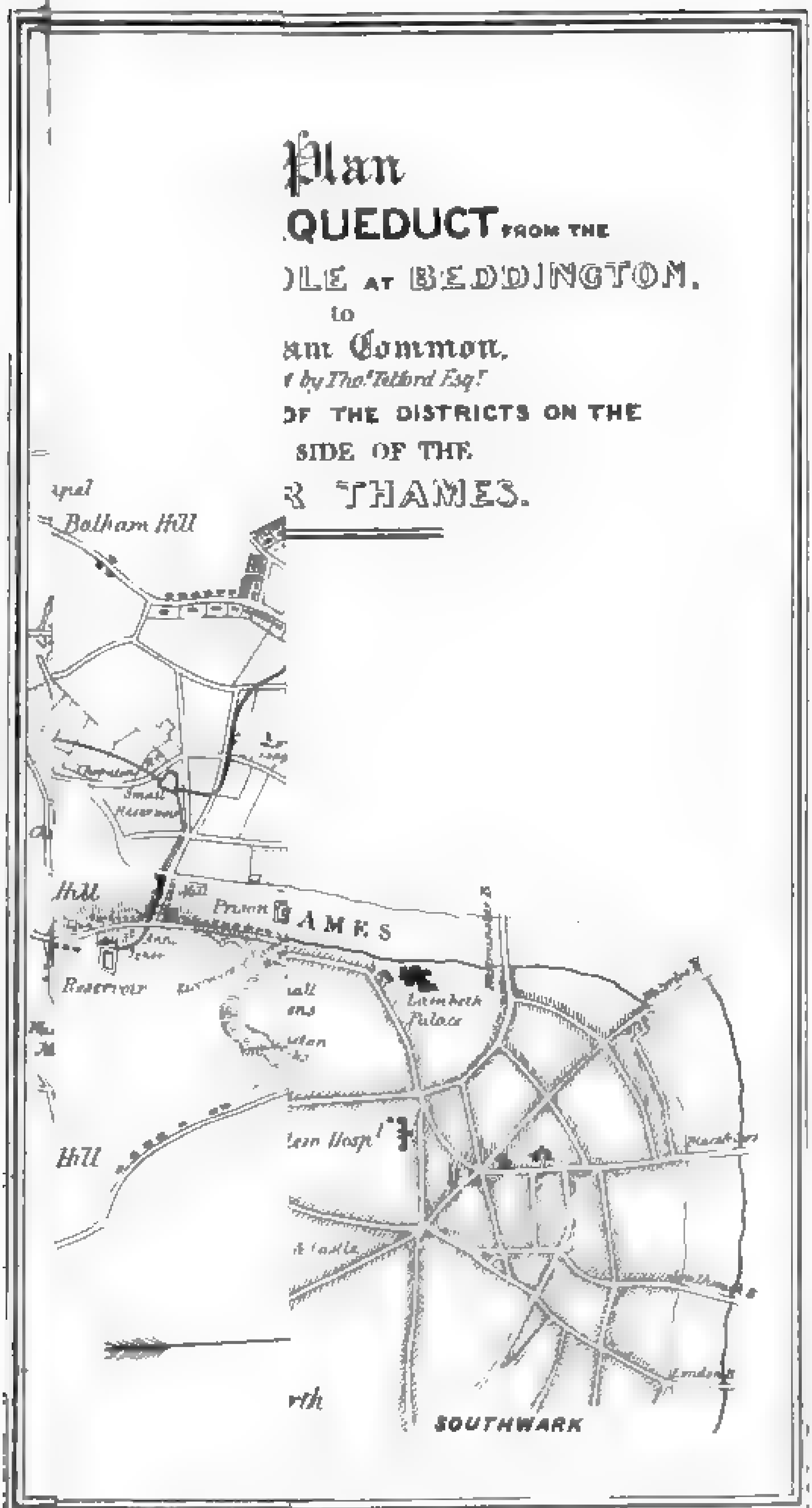
The plan proposed for supplying the south side of the Thames, consisted in forming an extensive reservoir on Clapham Common, to receive water procured from the Croydon branch of the river Wandle, at the east end of Beddington Park, being a point ninety feet above high water in the Thames. A covered aqueduct with a double water-course and foot-path interposed was also to

* In the present Session (1835), the Grand Junction and Chelsea Companies have applied for Acts of Parliament, to enable them to obtain water higher up the Thames; the former at a place opposite Richmond Gardens; the latter at a short distance from Richmond Bridge.

be the means of conveying it to Clapham; and thence by iron main pipes to the Lambeth, South London, and Southwark Water Works. The estimated cost of this scheme was 391,875*l.* 4*s.* 11*d.*, making the expense of realizing both plans, 1,177,840*l.* 16*s.* 5*d.*; but although so nearly calculated, even to odd pence, probably double the sum would not liquidate the cost of executing works of such magnitude.

Another important consideration relating to these projects, consisted in the pecuniary means, which it was proposed the government should advance, and the Water Companies charged with the interest. Besides, it also embraced the appointment of a "*Parliamentary Commission to manage the whole*, in order that the necessary works may be performed in a satisfactory manner, and that the water may be correctly supplied in quantity and quality to each company." Mr. Telford, however, seemed to entertain doubts whether the supply to be afforded by incurring such an enormous expense, and having the costly appendages of a Parliamentary Commission, may not prove unsatisfactory; and therefore he concludes with observing that, "until the public have, *by experience*, acquired a perfect confidence in the *quantity*, *quality*, and *regularity* of the *pure water* supply, *the communication with the river* (Thames) *ought to be preserved*, but not used, unless *necessity* for so doing *should occur!*"

Though the New River and East London Works were excluded from his scheme, Mr. Telford made some remarks on their condition and capabilities. As the Amwell spring "had abandoned the New River, and now finds its way into the Lea," he suggested that "an old branch of the River Lea, at present not in use, should be transferred to the New River Company, who should be


Plan
QUEDUCT FROM THE
LE AT BEDDINGTON.
to
am Common.
by Thoˢ Telford Esqʳ
OF THE DISTRICTS ON THE
SIDE OF THE
R THAMES.
Balham Hill
Small Reservoir
Hill
Prison
AMES
Reservoir
Lambeth Palace
Hill
rth
SOUTHWARK

required to embank and enlarge it, to not less than twenty acres, and convert it into a settling reservoir, upon which the pumping engines should be placed,—the engines to be capable of raising two-thirds of their whole supply. This additional quantity thrown directly into the reservoirs at Newington, would have the advantage of being in the vicinity of the city, and create no further expense of conduit, or other conveyance." If this plan were carried into effect, the Company were to be required "to rebuild the lock at Tottenham Mill, as well as to keep it in repair, and also to pay a fair and reasonable sum to the trustees of the River Lea Navigation to be expended in deepening the river where found necessary." Various other improvements of the New River were likewise enumerated, for instance, "fencing each side of it in a proper manner, to prevent cattle treading down its banks, persons bathing in it, and creating other nuisances." He also stated that "the Company should have the power of summary punishment of trespassers on conviction before magistrates;" and that "Parliamentary Commissioners should be appointed to decide any differences which may arise among parties interested in the supply and purity of the water to prevent expensive litigation."*

With regard to the East London Water Works, Mr. Telford states, that recently "upwards of 50,000*l.* have been expended in improvements for ensuring a better supply of pure water, which are on the eve of completion; and these had been effected without the Company having the power of imposing additional rates or charges on their customers." He further affirms, that "a personal inspection of the Water Works at Old Ford," convinced

* The New River Company have since applied (in 1835) for an Act of Parliament, to enable them to effect these and other purposes.

him of their efficiency, and that any suggestions from him "had been anticipated."

The above is a fair outline of Mr. Telford's plans, and a faithful abstract of the principal points in his Report, which, on the 12th of May, 1834, were referred to the consideration of a Select Committee of the House of Commons, on a motion made by Sir Francis Burdett. As the subject occupied their attention during the remaining part of the session, and the proceedings have since been printed by an order of the House, a summary view of the most striking parts of the evidence, will enable any candid person to decide whether the chief aim of some professedly zealous and patriotic personages was really "the *better* supplying *the whole of the metropolis* with *pure* and *wholesome* water," or to procure *a lucrative job* for themselves, at an *enormous expense to the public!*

From the apparent solicitude of Sir F. Burdett to employ Mr. Telford, many persons would naturally infer that his primary object was really to procure from that engineer a scheme displaying so much thought, ingenuity, science, and skill, as to surpass all the previous contrivances for supplying water to a great city. Incredible, however, as it may appear, he neither entertained such a notion, nor intended Mr. Telford to be employed, notwithstanding his frequent and urgent solicitations to that effect, as well as for thousands of the public money to pay him for his labours! This fact is attested by himself, in the following most remarkable declaration to the Committee—"I considered Mr. Telford's *name* was the main thing that was necessary, and that he should confirm and approve; but *my reliance was always on Mr. Mills!*"—"For *five* or *six* years Mr. Mills was the person whom *I had always referred to*, and *always applied to!*" —"I considered *Mr. Mills was most essential to me*, in

getting the surveys made, and *the whole business done; I relied entirely on Mr. Mills*, and *submitted all to him!*"*—Such are the acknowledgments of a man who had previously enjoyed a high reputation for frankness, sincerity, and honour; and certainly, in this instance, he ingenuously disclosed his *real* views, and explicitly named his "guide, philosopher, and friend!"

Having heretofore noticed Mr. Mills' assertion that he "had employed *gentlemen* as well as himself to get up petitions, to complain of the water;" and also that the Commissioners applied to have "some person *acquainted with engineering* as their secretary;" a few of the "civil engineer's" own statements to the Committee of the House of Commons, in 1834, will elucidate some of the transactions that have long engaged the attention of Parliament and the public. After the mention of his attending Willis's Rooms, and there stating "his opinion that the whole of the supply from the Thames was *objectionable;*" and Mr. Telford being desirous to decline the office of Commissioner, yet at his *earnest request* consented to take

* *Minutes of Evidence*, 1834, p. 56. The perusal of these declarations excited some unpleasant feelings in the writer, and strongly recalled to memory the following passage in his remarks on the Report, &c. of the Commissioners, published July 1, 1828. "The noble-minded and patriotic baronet has had some mortifying experience of *politicians* by *profession*, and may he not suffer either in *character* or in *cash* from Water Company projectors? If some of the "*engineers of eminence*" should induce Sir Francis to supply the pecuniary means for realizing their *ingenious* plans, perhaps he would ultimately share the fate of Sir Hugh Myddelton, without producing any benefit to the public. Have not the *plans* and *calculations* of some "men of eminence" been remarkable, only for a *pre-eminent* lack of knowledge and judgment?" The pamphlet containing the above was referred to, and the author's name mentioned, by one of the Select Committee appointed a few days after it appeared.—*Minutes of Evidence*, July, 1828, p. 17.

a part in the inquiry, solely on the condition of his undertaking to be "*pioneer*," so that he actually engaged to "*do all the executive department*,"—Mr. Mills thus proceeds. "As soon as the commission issued, Dr. Roget, Mr. Telford, and Mr. Brande, *applied to the Treasury for leave to name their assistant.* Lord Lansdowne took another view of the question, and said he did not see the necessity of having an engineer as assistant to the commission, and that those gentlemen had mistaken the extent of their powers, and that they must confine themselves to the *quality* of the water, and the *quantity*, but *not go to the remedy. I undertook the whole of that inquiry*, as far as the *engineering* department went, and gave the result to Mr. Telford." In reply to the question—"Why he camé to do what he did, when the Commissioners were not authorized *to employ a civil engineer?*" He made the following asseveration:—"I was *quite ignorant* of any correspondence between the Commissioners and the Treasury upon the subject, till I gave in my report to the Commissioners, who expected to have had power to *remunerate me!*"

"When Sir Francis Burdett thought it necessary to have a Select Committee of Inquiry to take the Report into consideration, he requested that *I should attend that Select Committee, and conduct the examination. I did so*, and it terminated in the Committee recommending that Mr. Telford, *one of the previous Commissioners*, should be allowed to make a Report upon *the best mode* of supplying the metropolis with water." * Such is Mr. Mills's own narrative of his operations relating to a business, which has occasioned not only some anxiety to the residents of the metropolis, but likewise considerable expense to the public.

* *Minutes of Evidence*, 1834, p. 29.

If the statement of Mr. Mills be correct, he was the Alpha and Omega of the inquiry; he was the orator at Willis's Rooms; the "pioneer" and "assistant of Mr. Telford;" the "engineer" to the Commissioners; the "confidential *scientific* friend"* of Sir Francis Burdett,

* These designations are quoted from the Correspondence and Minutes of Evidence, and if considered in connection with the assertions of Sir Francis Burdett, will perhaps justify the suspicion of Mr. Mills having "lent a helping hand" in composing the Report of the Commissioners, as well as that of the Select Committee in 1828. Several of the letters addressed to the Treasury with the signature of F. Burdett, have a striking similarity in style and matter to other documents signed T. Telford, though Mr. Mills declared they were written by himself. The Committee of 1828, recommended "*the immediate employment* of Mr. Telford to proceed in making *such surveys as he shall think necessary;*" and Mr. Telford, in a letter printed with it, addressed to Sir Francis Burdett, stated Mr. Mills to be "*a proper person* to delineate any line of water-course, &c." The latter also averred, "that the affair of a former survey for the Commissioners, was *understood* between Mr. Telford and himself!" Thus the same individual appears as an originator of Parliamentary proceedings; and if his own and the Baronet's declarations are to be relied on, probably he was either the prompter or amanuensis for applications to the Treasury to "remunerate him" for *the job*. Moreover, the Baronet affirmed that "he *relied entirely on Mr. Mills;*" often and urgently as he had named Mr. Telford, whose plans formed the chief topic of his addresses to different Committees in 1834, on Bills for the improvement of Water Works; when, with Mr. Mills at his elbow, he endeavoured to dissuade the parties from proceeding, till a Committee of his own nomination had decided on a scheme for the whole of the metropolis. It was on this latter occasion that the fact became known of a quarrel between Messrs. Telford and Mills, about the division of the 5000*l.*—each being desirous, as a well-informed gentleman stated, to have "the lion's share." At the commencement of this business, it will be recollected, that one of these *honourable* personages stigmatised the Water Companies as a "mischievous and *unprincipled* confederacy;" but are the professedly zealous advocates, for what they call *pure water*, exempt from the imputation, of something like collusion *to delude* the public?

"to conduct the examination at the Select Committee;" and finally, "the colleague" or "assistant" to Mr. Telford to make the surveys, that have cost the nation 5000*l*., of which sum he has probably had a large portion.

Singular and striking as may be the circumstances in the preceding detail, others were developed deserving peculiar attention. Prior to the appointment and meeting of the Select Committee of 1834, it had been insinuated that the plans delivered to the Treasury by Mr. Telford, were neither contrived by himself, nor the results of his own surveys. Hence the Committee put to him the question—"Who superintended those surveys;—was it Mr. Mills?"—and Mr. Telford's answer was—"No; it was I myself. I superintended everything—the surveys, plans, and estimates. All the plans and sections were laid down, and estimates made out in my office."* At the same time he delivered a memorandum of the names and occupations of the individuals employed. For instance, "Thomas Casebourne, George Turnbull, Bryan Donkin, W. Cubitt, John M. Neil, taking levels, laying down maps and sections, measuring water, making calculations of quantities, estimating the value of works, and especially mill power." "James Mills in *perambulating the country*, taking trial levels, &c." The five individuals first named, were also examined by the Committee, and corroborated Mr. Telford's statement.

The Committee interrogated Mr. Telford with respect to his reasons for proposing the Verulam and Wandle as the sources of supply; and he gave for answer, the competency of the Verulam to "supply 30 cubic feet per second, which is more than double the quantity the three

* *Minutes of Evidence*, p. 7.

(Western) Companies have now; and he intended the water to be delivered *without pumping* or *filtration*, to the highest necessary level." However, he acknowledged that some very obvious and important points had escaped his notice and consideration: such as "the injury that would be sustained on both sides of the river, by the abstraction of water required for irrigation, ornamental water, and that containing fish;"—nor had he "asked the owners of mills what would be the amount of damage to them; but had employed Mr. Bryan Donkin and Mr. William Cubitt, men much experienced in mill property, and proposed making compensation by steam-power, according to the proportion of water taken from each mill." * Mr. Telford was also questioned concerning various other circumstances of inferior importance, and therefore unnecessary to be narrated.

It may not be irrelevant to remark that several months previous to the completion and delivery of the Report and Plans to the Treasury by Mr. Telford, a quarrel had occurred between him and his assistant, Mr. James Mills, whose singular and preposterous statements have heretofore been noticed. When this person was examined by the Committee, it seemed to be his principal aim to elevate himself by depreciating his former employer, and representing him to be incapable of the exertions required by the surveys, on account of "his age and infirmities." Among other assertions, he stated it to be "his belief, that from the *very first commencement of the enquiry*, he had conducted the whole *under the name* of Mr. Telford;" and having finished the "perambulation" according to his instruction, "they went together in a post-chaise, to the various points whence the water was to be

* *Minutes of Evidence*, p. 6.

brought, and that "Mr. Telford never saw any more of the country than what he could see out of a post-chaise!"* To this was added, his accompanying Mr. Cubitt in the valuation of mills; his procuring specimens of water from the Verulam, Colne, Wandle, New River, and the Thames, to be analysed. He also stated that he alone pointed out various lines for aqueducts, sites for reservoirs, &c. to Mr. Telford, with which the latter "was delighted." If the relations of Mr. Mills be correct, *surveys* and *plans* constituted the chief object of attention through the whole course of their proceedings, although the *quality* and *quantity* of the water really were the primary considerations, and the ostensible purpose of their being employed. Nevertheless, surveys were made, plans for aqueducts and reservoirs formed, without waiting for any analyses of the water, which might on examination prove to be inferior to that already supplied, as well as the sources not sufficiently abundant for the purposes of the metropolis.

Day after day were the Committee occupied in listening to Mr. Mills's tedious and extravagant details relating to the projects of Mr. Telford and himself, apparently to show that whatever merit appertained to the *surveys* and *plans*, must be attributable to his own *superior ingenuity!* As an illustration of this self-complacency, one instance may suffice, which he affirmed to be "his own *invention entirely*, and Mr. Telford appeared exceedingly *delighted* with it." The device consisted in "perforating a chalk hill, situate between the rivers Verulam and Gade, so as to bring the water of both rivers into one focus; and when the millers had ceased to work on a Saturday night, to turn the stream into some large reservoirs constructed

* *Minutes of Evidence*, p. 16.

for the purpose, by which means he calculated on obtaining before Monday morning, *as much water as would supply the metropolis for a week!*"* Such a *rational* and *feasible* operation, he stated, would effect a saving of 385,000*l.* the sum proposed to be given to the millers as "a compensation for water taken from the mills!"† This grand economical project excluded all consideration of any inconvenience being experienced by the millers, from the want of water on a Monday to work their mills, or whether the sources would be adequate to supply it! In the course of his recitals to the Committee, Mr. Mills repeatedly affirmed that Mr. Telford was "delighted" with the various schemes proposed by himself; but if the latter really thought them admirable, it is rather surprising that not one of the *delightful* projects should be deemed worthy of his adoption! Indeed Mr. Telford stated that Mr. Mills "recommended many things which he did not approve; and although he would lead the Committee to believe that he devised the whole of the plans, nevertheless he was merely in his employment; knew he was in great favour with Sir Francis Burdett; was glad to give him all the credit he deserved, but wanted none from him."‡

The preceding detail refers chiefly to the schemes for supplying the metropolis on the north side of the Thames, but Mr. Mills had also a variety to effect the same object on the south. Indeed he seems in fertility of invention to have been desirous to resemble the celebrated Abbé Sieyes, whom Mr. Burke described as possessing pigeon-holes full of projects, so as to be prepared with a plan for every conjuncture. Hence, from his abounding store, the Committee were presented with

* *Min. of Evid.* p. 17. † *Ibid.* p. 23. ‡ *Ibid.* p. 32, 33.

no less than four different plans for the supply of the south side of the Thames. One of them had for its object to take water from the Thames between Kingston and Moulsey Lock, and to convey it to a reservoir on Wimbledon Common, at the estimated cost of 141,856*l*. Another scheme consisted in taking water from the Thames immediately above Teddington Lock, and to convey it by a tunnel under Richmond Park, to the same reservoir, at the estimated expense of 167,476*l*. A third was a proposal to remove Teddington Lock to a place below Richmond, and thence convey water from the Thames by a conduit to Barnes Elms Estate, that the West Middlesex, Grand Junction, and Chelsea, might pump from that place to their respective works. The estimate for this was 116,732*l*. The fourth plan proposed to take water from the river Wandle at the head of Watney's Flour Mills, below Wandsworth Bridge, and after conveying it to a reservoir in Battersea Fields, to pump it to another reservoir on Clapham Common. Besides, it comprised the construction of a second reservoir, directly opposite the Grand Junction and Chelsea Companies' engines, for these establishments to take their supply;—procuring the water on a Sunday also formed a feature in the plan, to avoid giving compensation for mills;—the estimate was 97,000*l*. * As an appendage to his various plans, Mr. Mills proposed to have a filtering reservoir of about two acres, with two feet head of water, which was to "enter at the bottom of four rough walls, and rise through the filter to overflow the top of the walls." This, he averred, "would be sufficient to filter a whole week's supply," which was to be afterwards taken from a reservoir calculated to con-

* *Minutes of Evidence*, p. 109.

tain enough for a month. He was asked whether "the water after filtering in the summer, and being stagnant for three weeks, would not generate insects and vegetation?" When he replied—"It never could be stagnant for three weeks, for if he put in one week's supply every week, that was quite sufficient to keep water of that magnitude in the most perfect purity!"* This answer shows the *consistency* of the philosopher, who, in his former "Statement to the Commissioners," had represented the Thames as "likely to become *putrescent*," though *constantly in motion!* To the several instances already adduced of the extraordinary pretensions of the "assistant to Mr. Telford," one more may be added affording a striking display of his superiority to all competitors. In the account of his assertions to the Committee of 1828, the reader will recollect that his answer to one question was—"*I am not engineer enough* to devise any plan, by which we can convey to the pipes of *eight* different Companies water at a high level. *I have no idea* of the *practicability* of such a measure."† Nevertheless, to the Committee of 1834, he affirmed that "*one single pipe*, of *six* inches diameter, brought down from Primrose Hill, will supply the *whole high service of London!*"‡ Experience however proves, that to effect the high service of a *single* Company, actually requires the use of a pipe twenty-one inches in diameter. How many such pipes must therefore be necessary to supply all the others? But if this "*civil engineer*" possess such matchless capabilities, is it not palpably evident that—

"None but himself can be his parallel?"—

And to compare the constructor of the *Menai Bridge*

* *Min. of Evid.* p. 107. † See p. 390. ‡ *Min. of Evid.* p. 153.

and *Cysylte Aqueduct* with him, would be contrasting objects most strikingly discordant!

Having given a faithful outline of the schemes proposed by Messrs. Telford and Mills for supplying the metropolis, it may be useful to add some remarks that were made by others upon their respective merits; and their statements will probably show whether the *eminent* engineer, or his coadjutor possessed the appropriate qualifications for undertaking to afford "a better supply of water," than the inhabitants previously enjoyed.

Among the persons examined by the Committee was Mr. W. Anderson, the engineer to the Grand Junction Water Company; a man whose clear perceptions, and cool discriminating judgment being united with science and skill in his profession, render his statements worthy of peculiar attention. Besides, he was well acquainted with all the localities that formed the basis of the plans, as well as the different rivers from which it was proposed to obtain water. He observed that "Mr. Telford stated seventy-two cubic feet of water per second, which in twenty-four hours will give 6,220,800 cubic feet for the produce of the Verulam and Gade united; and this being only one-third of a week's consumption, it would therefore require *three* days water instead of *one*, as stated by Mr. Mills, to be delivered into the reservoir for a week's supply." Besides, "if such a plan were adopted, a great portion of the branches of the Colne would be *left dry for three days;* for instance, in those parts from the head of the mill to the tail, whatever the fall might be; *thus the mills would be stopped for want of water three days and a half out of the seven.*" Hence, there being 35 mills below the points at which it was proposed to take the water, it would be necessary to purchase

every mill on the stream, exclusive of the amount required for injury to ornamental waters to gentlemens' seats. The junction of the Verulam and the Gade, would be an expense of 139,000*l.*; * and estimating the mills at 355 horses' power, the compensation for them alone would be about 450,000*l.* † It appeared likewise that the Verulam received drainage from the towns and villages situate on its banks, as is probably the case with every other river, and consequently must be equally objectionable with the Thames.

At different times Mr. Anderson has made experiments with a float, to ascertain the point to which the tide ascends in the Thames, and the results several years ago showed that it flowed to near Hammersmith; but his last, in 1834, proved that since the removal of Old London Bridge, it runs about two miles higher up, besides having a quicker motion, which has had the effect of cleansing the banks and bottom of the river. Hence, very little mud is perceivable in the Thames to near Mortlake; and although it increases in its course, it is so trivial in the vicinity of Battersea Bridge, as to have no sensible effect on the water. From the attention bestowed by him on the state of the river, he concluded that the water taken at Barnes Elms, during ebb and flood, in the manner proposed by the West Middlesex Company, would be nearly as good as at Isleworth, but should prefer water taken opposite Sion House, because generally it would require very slight filtering. To effect this, it would require a conduit three and a half miles in length, which would cost from 30,000*l.* to 40,000*l.*

The purity of the water near to Teddington, having been often the subject of remark, Mr. Anderson endea-

* *Minutes of Evidence*, p. 67. † *Ibid.*, p. 68.

voured to calculate the average quantity that usually flows over the weir, so as to enable him to judge whether it would be adequate for an ample supply. To attain this object, he measured the distance of 100 feet on each side of the river, and ascertained the velocity of the stream in that space. Three sections of its depth were also taken at different points, which gave an average of three feet six inches, therefore taking the height of the water passing over the weir at one foot six inches, he estimated that the amount would be 54,412 cubic feet per minute, and this in five hours would fill the channel of the river at the average width of 200 yards four and a half miles in length: but the flow in summer being two feet in height, the quantity would occasionally exceed 75,000 cubic feet per minute. The whole of the water flowing down the Thames, Mr. Anderson calculated to be 123,000 cubic feet per minute.

The evidence of Mr. W. T. Clarke, engineer to the West Middlesex Company, and the constructor of the Suspension Bridge at Hammersmith, placed in a prominent light the absurdity of Mr. Mills's assertion, that "by a *six-inch* main from Primrose Hill, all the high service in London might be effected in *four* hours." He stated it as a fact, that it actually requires "*ten and a half hours* per day, to supply the high service of that Company's district alone, from a twenty-one inch pipe; hence, a six-inch main having only about *one-twelfth* of the capacity of a twenty-one inch, it would require 126 hours to perform the same service by a six-inch pipe!" Mr. Clarke likewise corroborated the testimony of Mr. Anderson, with regard to the tide ascending higher since the removal of Old London Bridge, and the increased velocity of the stream having had the effect of rendering the banks of the Thames more free from silt than formerly,

so that the condition of the water is materially improved at Barnes Elms, where the West Middlesex Company intended to construct reservoirs, and procure their supply of water. The plan was to take it at half ebb of the tide, for about four or five hours each tide, making from eight to nine hours in the twenty-four, the water being then in a very pure state. It was to flow from the river into a settling reservoir, afterwards to pass through a filter, and thence conveyed by a pipe to the well of the engine, to pass through the mains to the cisterns, without any exposure to the atmosphere.

As the object chiefly desired was *transparent* water, the Committee endeavoured to obtain from various persons the results of their experience, by the methods which they had practised. T. Marsland, Esq. M.P. stated that the filter employed in his works at Stockport, occupied about 500 square yards of surface, having a bed consisting of three feet of gravel, and three of sand, which was renewed once in two years, at an expense of about 40*l*. The water flowed into it directly from the river; and though its condition was worse than that in the Thames, it passed through instantly, so as to filter 500 gallons in a minute. Its surface was occasionally cleansed at the cost of about twenty shillings.

Mr. J. Simpson, engineer to the Chelsea Company, enumerated some particulars concerning the filter employed at those works. He stated that the filtering began to operate with about four inches head of water, and continued working till it reached five feet, that being its usual height. Though occupying only one acre, it purified in twenty-four hours rather more than 2,300,000 gallons. According to the analysis of the water by Dr. Bostock, 10,000 grains of the water contained only about

two grains of extraneous matter, so that its purity must be equal to any spring water.

The Committee were engaged in this inquiry, at intervals, for nearly three months, and examined Mr. W. C. Mylne, engineer to the New River Company, Mr. T. Wicksteed of the East London, Dr. Bostock, and various other persons relative to the object of their appointment. Mr. Mylne recounted different improvements that had been recently effected, and others that were in contemplation for increasing the supply; at the same time, he affirmed that Mr. Telford's proposal was only what the New River Company had in view some years ago, having actually introduced a Bill into Parliament for the purpose, but on account of powerful opposition it was abandoned. Mr. Wicksteed detailed the very important improvements in the works that he superintended, and remarked upon Mr. Mills's erroneous and extravagant assertions concerning them. To show the fallacy also of his notion about supplying high service, Mr. Wicksteed observed, that according to Mr. Smeaton's experiments upon the friction of water passing through pipes, it is necessary to have 121 feet head of water to overcome the friction produced by a velocity of five feet per second, through a six-inch pipe, for every mile in length. Thirty feet per second is equal to twenty miles per hour; and as the friction, and consequent head of water to overcome that friction, increases as the square of the velocity, it would require an immense head or column of water to overcome it; hence, he considered it quite impracticable with the head of water from Primrose Hill, to produce a velocity of thirty feet per second through a six-inch pipe of a mile in length. Even if water could be made to pass through a six-inch pipe at the rate of thirty feet per

second, it would not deliver six cubic feet per second at the distance mentioned.*

The circumstances that have been related clearly display the nature and extent of Mr. Mills's qualifications to afford "a better supply of water to the metropolis," than that which is supplied by the present establishments for the purpose. Though at the commencement of his career he professed to possess only "a slender portion of common sense," yet his confident pretensions and assumptions inevitably lead to the conclusion that he considered himself to be such a superior genius, that Mr. Telford and others were mere pigmies in a comparison with himself. His extravagant asseverations so astounded the Committee, as to induce them to examine several other well-informed persons, besides those already mentioned, and the whole concurred in declaring his statements and calculations to be fallacious. Indeed several considered them "so preposterous, as to deem it a waste of the Committee's time to comment upon them." Such, however, was the oracle of Sir Francis Burdett in this affair; and the baronet's patronage of his views, has probably cost the nation from ten to twenty thousand pounds, without benefiting a single human being, excepting the "surveyor" himself, and a few of his coadjutors.

If the metropolis should not be well supplied, the defect will not arise from any lack of projects for the purpose; and it may not be uninteresting to notice that Mr. Martin, the artist, presented to the Committee the plan proposed by him in 1828, with some alterations, an appropriate map, and a drawing to represent a rail-road. In this, his object was not only to procure water from the Colne at Denham, where the different branches unite to

* *Minutes of Evidence*, p. 162.

form one stream, but to convey it to Paddington by a covered aqueduct, having upon it a rail-road fourteen and a half miles in length, at the estimated expense of 569,500*l.* From this source, he stated it to be his intention to furnish a supply for the West Middlesex, Grand Junction, and Chelsea Companies' districts; but as he had not strictly ascertained the quantity of water to be obtained, on subsequent inquiry it appeared that it would amount merely to "about one-fourth of the maximum quantity proposed;" and other circumstances evinced a want of that scientific and practical knowledge which are essential for contriving and the construction of Water Works. From documents delivered to the Committee, it appeared that in this instance Dr. Turner of the London University, and Dr. Kerrison, afforded their aid by what is denominated, "*a qualitative analysis*" of the water of the Colne, besides the latter engaging to "*illustrate the distinction* between *hard* and *soft* water!" *

Various notices have recently been given of intentions to apply to Parliament for Acts to improve the existing establishments, and to form others for supplying the metropolis, which will again occasion the subject to occupy the attention of the public. Among them appears a scheme for sinking "wells of 100 feet diameter, having a depth of 100 feet, or even more, until the pure spring water is produced." According to the estimate of the projector, "each of these will yield 100,000 barrels every twenty-four hours, and that *eight* of the Water Companies, deriving their supply from the Thames, by adopting this method, will be enabled to supply their tenants with *pure* and *wholesome* water;—twenty such wells being sufficient to supply the metropolis!" This

* *Minutes of Evidence*, p. 115.

is also one of the plans proposed to the Committee in 1828, by a Mr. Henry Francis; but on his examination, he admitted that the only grounds for his calculations of their probable great productiveness were—the quantity of water appearing in different mines in Cornwall and other places, as well as during the excavations of the West India Docks, the Thames' Tunnel, some borings at Tottenham, &c. He likewise acknowledged his inability "to speak *practically*, and could only argue by *analogy*." * At the time of the project being broached, scarcely any consideration was bestowed upon it; but a popular monthly publication has lately announced that a Mr. Robert Paten is about to submit to the borough of Marylebone, a plan and estimate for supplying the district, independently of Water Companies connected with river service.† A few extracts from the elaborate article containing this statement, will convey a clear notion of its tenour and object, and will also show how much it abounds with invective, assumption, misrepresentation, and dogmatism.

The writer begins his *tirade* by quoting from the Report of the Committee of 1828, some passages that were not authorised by credible evidence, and then sarcastically refers to the plans of Mr. Telford as disclosing the "wonderful discoveries of there being other streams and rivers, besides the Thames and New River, which may be brought to London, and served out from reservoirs for the public use." After designating the present supply as deleterious and poisonous, besides stating that

* *Minutes of Evidence*, 1828, p. 16, 17.

† *Frazer's Magazine*, No. 59, for Nov. 1834. The article is attributed to the author of "*Old Bailey Experience;*" and his assertions evince about the same attention to facts, consistency, and verity, as some others who have appeared to recommend new projects.

"pure water is the result of the combustion of two parts of oxygen to one of hydrogen by bulk, free from all adventitious substances, whether animal, vegetable, or mineral," he avers, that "almost every schoolboy knows that such a fluid is nowhere to be found on this terraqueous globe, except at the mouth of certain springs; and that *the farther* we recede from the source, the *more deteriorated*, and the less *transparent* will the water become."—"All pure spring or well water, very soon after it is exposed to the influence of atmospheric air, imbibes impurities, and is in a state of incipient *turbescency!*"—"No water can be considered pure which has been conveyed by a stream, and agitated in its passage over various soils, exposed at the same time to the effects of *the atmosphere, which is ever dropping vegetable impurities on its surface!!*"—"When *stagnant* or *in motion*, it may part with its *earthy properties*; but it uniformly takes up animal and vegetable matters which, being under the process of decomposition *impregnates* the water with *gaseous impurities*, destructive to the health of all who use it, either for culinary purposes, or as a beverage;—generating a variety of complaints in the opinion of Dr. Kerrison, principally those of the viscera, enlargement of the liver, dyspeptic complaints, &c." *

Notwithstanding such confident assertions concerning the "*gaseous impurities*" of the water being "destructive to the health of all who use it,"—and also affirming that "diseases are very prevalent in the metropolis in autumn," yet this strenuous but inconsistent advocate for *pure* water, has actually bestowed some pains, in the identical descant, to prove that in general the residents of the metropolis *are not water-drinkers!* Besides the

* For Dr. K.'s curious reasoning in support of such a statement see chap. xx., p. 396—400.

following confession will still farther show his acumen and logical dexterity, although at the same time professing to rely upon the authority of "eminent *medical* men!"—"Within these few years our medical knowledge has been *much enlarged*, yet but *little advance has been made in ascertaining the generating causes of diseases;* plenty of *theory*, but *no facts*. We have *increased our nosological nomenclature*, and can give the *derivation* of our *new terms*, but *are unable satisfactorily* to trace *old* or *new* diseases to their source!!"—Again—"It is curious and interesting to observe the manner in which palpable truths are frittered down, and become lost to the public, by the ingenuity and *disingenuousness* of scientific men, when called upon *to support particular interests*. They deal with *axioms* and *facts*, as if they were *hypothetical;* and with *hypotheses* as if they were *facts*, just as in turns it serves their purpose!!"—The sagacious writer of such a description surely did not suspect how appropriately it might be applied to himself, when among his other assertions, he actually intimates that *it may be* the "generating cause" of the cholera!

Having so aptly illustrated his own position concerning *ignorance* of the *causes* of diseases, he thus boldly proceeds:—"The charges against them (the Water Companies) are, that they know their supply is bad,—nay *destructive to health*. This fact has been proved so often that none can pretend ignorance of it. Their *charge for the water* they do supply is *most enormous* and *oppressive upon the poorer classes;*—the probable average to each house throughout the metropolis being from *three* to *four* pounds per annum! * They know there is a better and

* See the tabular view of their respective rates, &c. at the end of the work, from which it will appear that the charge does not average in amount, half the sum named by this writer; and for a very large number of houses it is only ten, twelve, or fifteen shillings.

as ready a supply at hand, but from a principle of monopoly that actuates all their measures, and from the all-absorbing motive of gain, they oppose every attempt for improving the supply, although it may tend to remove a vast number of diseases, and promote the longevity of the London operatives generally!"

Though the writer reprobates "a joint-stock company as a *juggle*, with the *humbug* of *paying interest on capital*," nevertheless, he states that if the inhabitants of Marylebone borough take upon themselves to manage their own supply of water, they will be able to *pay* good *interest* for the *capital* required! However, he affirms, that "*the Government ought to undertake it*, and that the money might be *borrowed* and *added to the national debt!*" Thus to enable the sage contrivers of this dubious project to realize the professed purpose of benefiting a wealthy portion of the community, it is proposed that the whole nation shall be burthened with the expense and risk of their experiment, although the present average charge for water amounts only to about one farthing per barrel,—a *lower rate* than in any other great city. The impropriety of stigmatizing such a trivial sum to be "enormous and oppressive," is as glaringly obvious as that facts and veracity have been disregarded in this attempt to recommend an expensive scheme, which has chiefly for its basis—"*hypothesis!*"

Wherever the inhabitants of a populous district depend upon wells for their supply of water, the uncertainty and variableness of its quantity, often expose them to great inconvenience, arising either from long periods of dry weather, or the springs finding their way into other places. The latter was the case of the prolific spring at Amwell, which formed one of the original sources for supplying the New River, but its produce has long since flowed into the Lea. Common as is the expression—

pure spring water, and generally also as the notion may be indulged that when obtained from wells, it is freer from admixture with other substances than that afforded by rivers, nevertheless the recent analysis of the transparent water from the Treasury pump at Whitehall, shows it to contain extraneous matter to the amount of four times the quantity of the Thames at Hammersmith, and the filtered water from the Chelsea Works. Numerous facts of a similar kind might be adduced to demonstrate that *transparency* cannot be deemed a proper test of the *purity* of water; and although the above instance is one irrefragable *proof*, has its *salubrity* ever been questioned by the *medical attendants* of those who have long and constantly used it for beverage and other domestic purposes?

The calculation of the productive power of springs in London and its vicinity, is evidently founded on a fallacious principle; for although holes have been bored to a great depth in various places, four, six, or eight inches diameter, and water has in some instances actually risen to the surface, can these be deemed sufficient reasons for a conclusion, that the same sources would furnish a constant supply for wells of several hundred times the capacity! For a few domestic purposes, wells of moderate dimensions yield but a limited supply; and even if they were twenty times the magnitude, how trivial would be their aid in various important cases, particularly in the emergencies of fires, when to extinguish the conflagration at a single house commonly requires nearly a thousand hogsheads? And would they contribute any share of the supply for cleansing the sewers, and watering the streets in summer?

It may not be unuseful to remark, that one reason assigned for the feasibility of supplying the metropolis

by means of wells, is the exuberance of water afforded in former ages by the springs at Bayswater, and other places, when the population did not amount to one-fifth of its present number, and their habits and occupations required a less ample supply. However, the deficiency of those sources at that period occasioned a recourse to the Thames and the construction of the New River; besides the bad quality of the water procured from many wells in Southwark, was the cause of the inhabitants obtaining it from the Thames, much as this noble stream may have recently been decried by sordid projectors, or medical practitioners, who have proved themselves to be incompetent to appreciate its genuine properties. The different concurring projects that have lately been announced for obtaining it from this ample source, indicate that the various examinations of its qualities, prove it to be equal, if not preferable, to any other for the supply of London.

As a conclusion to this account of the numerous and diversified contrivances to accomplish the momentous object of supplying water to the population of great cities, it is hoped that a few reflections will not be considered irrelevant. Various facts related in the preceding pages, have shown the fallaciousness of the assertion that the refuse from different manufactories imparted deleterious qualities to the Thames; and perhaps no statement was ever less supported by rational and credible testimony. It is indeed far from improbable that the substances, to which the term *refuse* was applied, have a tendency to promote the decomposition of *animal* and *vegetable* matters, and really operate to render the water pure and wholesome. If the water be turbid, it may not be either filthy or noxious; and generally it becomes transparent in a short time, if kept still to allow the subsidence of the particles which occasion its opaque ap-

pearance. The fastidious may call mud and manure filth, yet do not such substances communicate fertility to our fields and gardens, whence we derive the choicest productions both for sustenance and gratification? But does any rational creature ever suspect that the "decayed animal and vegetable matter" *pollutes* these sources of health and enjoyment? Though sordid speculators upon the credulity of mankind have broached preposterous notions, and excited apprehensions to realize their own purposes, do not facts prove them to emanate from *imagination*, to aid an attempt to substitute *prejudices* and *conjectures* for deductions from many scientific experiments carefully made, and also the testimony of experience?

The following facts will likewise afford a farther illustration of the subject, as well as useful materials for reflection. When the ingenious Dr. Beddoes was engaged with others in his inquiries concerning the causes of *consumption*, he found that scarcely any instances of that melancholy and fatal disease occurred among persons employed in various works, whose *refuse* some medical men have represented to be injurious to the Thames. In chemical laboratories, gas-works, tanneries, &c. &c. the workmen pursue their occupations amidst *offensive smells* without any diminution of health or appetite, and present a palpable contradiction to the statements and inferences of some conspicuous dealers in pills and potions. Besides, after the celebrated philosopher Dr. Priestley had invented his eudiometer, he ascertained that the *air of* narrow and populous streets in a large town, actually contained *the same portion of oxygen gas*, as others that were differently situate and spacious. This is *one* striking instance, among many, of the processes constantly and invisibly

going on to produce a salubrious atmosphere to our planet, as well as to preserve its *equilibrium* in the system; and chemical science has proved that, in numerous other cases, *analogous processes* concur to effect the same object.

Among the most conspicuous in sanctioning the delusive representations, that the water of the Thames was actually "deleterious," appeared several of the solemn-visaged and silver-tongued profession, whose opinions are commonly relied upon in cases affecting health, and even life itself. But strong as were the terms employed by them to characterize the qualities of the water, their own statements proved that the notions they broached concerning it were not very correct, and originated in conjectures, or unauthorized inferences. Perhaps, however, like the Egyptian priests in ancient times, they have *exoteric* and *esoteric* doctrines,—the former for the public, and the latter for the initiated. Because a small portion of sulphuretted hydrogen, or saline matter, happened to be mixed with the immense mass of water forming the stream, they depicted its qualities as "injurious to health," and "likely to produce some fatal epidemic;" yet with palpable inconsistency, their *frightened, if not afflicted* patients are sent to Bath, Cheltenham, Harrogate, and other places, where the same or similar substances constitute the principal ingredients in the water! Indeed some modern "oracles of health" have frankly confessed that cases of *hypochondria*, formed a source of their most profitable practice; and others may have cherished the desire of rendering it more lucrative by appending to it—*hydrophobia!* Their confident assertions are recorded in public documents, and incontrovertibly demonstrate that the potent and creative faculty—*imagi-*

*nation**—furnished the chief materials for their terrific picture of the condition of the Thames; and whilst pretending to much knowledge of its properties and effects upon the human frame, actually exposed their own deficiencies.

Though the preceding remarks may be strictly applicable to various individuals, yet to the same profession belong many men, whom every intelligent and discriminating lover of his species must admire and esteem, for the diversity of their talents, attainments, and virtues.

* The conduct of some of the 'yclept "*eminent medical men*" in these proceedings, excited emotions which it would be impossible for the writer adequately to express, for it recalled to memory many hours, when with agonizing solicitude he sat by the couch where beauty, intelligence, and moral worth lingered the victims of ignorance, cupidity, and craft. The complaint of an endeared relative was pronounced by one of her medical attendants to be merely *an affection of the imagination*, and he candidly said so; but another having impressed her with the notion of *his really understanding her constitution*—the usual cant of such practitioners—he administered pills and potions till *incurable debility* occasioned this lovely female to languish for years, an object of compassion for her sufferings, and admiration for her talents and virtues. But she was only a single instance of *three* sisters, who, from similar causes, have strongly exercised the sympathies, and roused the indignation of the author, to whom, about thirty years ago, a very clever young man, then assistant to his uncle, solemnly asserted, that the greater number of their patients had not actually any disease, except *an affection of the imagination!* Moreover, he affirmed that making pills with *bread*, mixing and bottling *coloured* or *camphorated* water, constituted a great part of his own employment in the surgery! The medical sages doubtless consider such admixtures perfectly *pure* and *wholesome* in their costly phials; hostile as they may apparently be to Thames' water, or the Water Companies, for charging about one farthing for thirty-six gallons! In numerous momentous cases have the defective knowledge and clashing opinions of this order been the subject of remark; and it yet remains to be proved, whether the recent parliamentary inquiry concerning the state of *medical education*, will effect any great improvement in their qualifications.

But unfortunately there are others, who claim the public confidence, without endeavouring to be entitled to it, either by the possession of useful knowledge or superior ability. Deplorably extensive is the mischief which such persons have the power and opportunity of producing in family circles, and how frequently have their dismal looks and pestiferous tales strongly affected the minds, and depressed the spirits of delicate females, whose confidence in their qualifications induced them to swallow coloured pills and potions, till health was irretrievably impaired, and their capacity for domestic enjoyment utterly destroyed? The instances of this kind of effect on female sensibility, so agonizing to the feelings of affectionate relatives and friends, are probably numerous, amongst the great population of the metropolis; and when those who profess to promote health and comfort, sap the foundations of both, by delusive pretences or exciting groundless alarm, can any reprehension be too severe that sorrowful indignation may have the power to bestow upon such conduct?

Finally, a variety of principles incessantly exercise their agency, and concur to effect important changes, that are subservient to the well-being and "perfection of this complex, stupendous scheme of things." Such mutations seem to be essential to the existence and support of animated beings, though persons possessing a scanty knowledge of the economy of nature may decry them, and dilate upon the *impurity* of both *air* and water, to attain temporary objects. But the light of science has enabled civilized and cultivated man to penetrate some of the astonishing recesses of nature; and by the vigorous exercise of his faculties, to discover many very curious decompositions and combinations, which accomplish the beneficent purposes of the Omnipotent Creator of the Universe.

A TABLE

SHOWING THE NUMBER OF HOUSES SUPPLIED BY THE WATER COMPANIES OF LONDON, &c.,

According to the Returns made to Parliament, in 1834.

Name of Company.	Number of Houses Supplied.	Gross Annual Income.			Average Annual Expenses.*			Height of Supply above the Thames.	Average Daily Supply to each House.	Average Charge for Water per House.†			Amount of Capital Employed.			Average Value of each Share.			Profit per Cent. on the Capital.		
		£	s.	d.	£	s.	d.	Feet.	Gallons.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
New River . . .	73,212	104,909	0	0	38,000	0	0	145	241	1	6	6	1,116,964	0	0	15,512	0	0	4	0	0
Chelsea	13,891	22,906	0	0	13,481	0	0	135	168	1	13	3	271,311	0	0	56	10	6	1	15	0
West Middlesex .	16,000	45,500	0	0	18,000	0	0	155	185	2	16	10	404,263	0	0	68	8	9	3	0	0
Grand Junction .	11,140	26,154	0	0	11,000	0	0	151¾	350	2	8	6	334,174	0	0	60	4	3	2	10	0
East London . .	46,421	45,234	0	0	15,889	0	0	107	120	1	2	9	594,988	0	0	118	19	11	3	15	0
South London . .	12,046	8,839	0	0	4,000	0	0	80	100		15	0	245,306	0	0	98	0	0	2	0	0
Lambeth . . .	16,682	14,808	0	0	6,500	0	0	185	124		17	0	182,553	0	0	144	17	8	2	2	6
Southwark . . .	7,100	7,850	0	0	No Return.			60	156	1	1	3	95,000	0	0	One person's property.			No return.		

* In this statement of Annual Expenses, there is no allowance to provide a fund for repairs, improvements, casualties, &c., which amount to a considerable sum.

† The Average Rate includes public buildings, breweries, distilleries, &c.; but the rate charged to many houses is only 10s. or 12s.; and all the water for extinguishing fires is gratuitously supplied,—the conflagration of a single house commonly requiring from 700 to 1000 hogsheads.

The number of Houses supplied in 1820, was 120,732; in 1827, 176,205; in 1833, 199,493; which shows an increase of 78,761 during 13 years, although considerably more than 10,000 houses have been taken down to effect various improvements, &c., and none erected on the same sites.

RESULTS OF EXPERIMENTS TO ASCERTAIN THE DISCHARGE OF WATER.

Interesting and important as is that part of Hydrodynamics relating to the conveyance of water, in pipes and open conduits, nevertheless, theory has afforded comparatively little aid, to guide the judgment of persons engaged either in constructing, or superintending water-works. However, in order to compensate for the defect, various individuals, possessing very superior mental endowments, have made numerous elaborate and ingenious experiments; and among the most celebrated, are the names of Smeaton, Brindley, Bossut, Du Buat, Prony, Girard, Venturi, and Michelotti. The following tables contain the principal results of their skilful and useful efforts, for the improvement of this branch of art.

TABLE I.

Shewing the quantity of Water discharged by Orifices of different diameters, in one Minute.

Height of the Water above the centre of the Orifice.			Form and Position of the Orifice.	Diameter of the Orifice in inches.	Number of cubic feet discharged in one Minute.
Feet.	Inches.	Lines.			
11	8	10	Circular and Horizontal.	6 12 24	2311 9281 37,203

TABLE II.

Comparison of the theoretical, with the real discharge of Water, from an Orifice of one inch diameter, at different heights, by BOSSUT.

Height of the Water in the Reservoir above the centre of the orifice.	The discharges as calculated from theory in cubic inches.	The real discharges from experiments, in cubic inches.	The Ratio of the Theoretical Changes.
Paris Feet.			
1	4381	2722	1 to 0·62133
2	6196	3846	1 „ 0·62073
3	7589	4710	1 „ 0·62064
4	8763	5436	1 „ 0·62034
5	9797	6075	1 „ 0·62010
6	10,732	6654	1 „ 0·62000
7	11,592	7183	1 „ 0·61965
8	12,392	7672	1 „ 0·61911
9	13,144	8135	1 „ 0·61892
10	13,855	8574	1 „ 0·61883
11	14,530	8990	1 „ 0·61873
12	15,180	9384	1 „ 0·61819
13	15,797	9764	1 „ 0·61810
14	16,393	10,130	1 „ 0·61795
15	16,968	10,472	1 „ 0·61716

TABLE III.

The quantities of Water discharged by Vertical Orifices under different heads of Water, according to MICHELOTTI's Experiments.

Height above the centre of the Orifice.				Diameter of the Circular Orifice.	Time of the Water running.	Cubic Feet of Water discharged.		
Feet.	Inches.	Lines.	Parts.	Inches.	Minutes.	Feet.	Inches.	Lines.
6	8	4	0		15	542	10	6
11	7	1	0	3	12	570	11	8
21	7	4	0		8	521	3	7
6	9	5	0		30	488	8	3
11	8	8	0	2	28	589	6	5
21	10	10	0		20	575	5	10
6	10	6	0		60	247	4	3
11	8	11	0	1	60	324	1	5
22	·0	2	0		60	444	6	5

TABLE IV.

Showing the results of Experiments made by Messrs. SMEATON and BRINDLEY.

Height of the surface of Water above the tops of the Orifices.	Form and Diameter of the Orifices.	Time of the Water running.		Cubic Feet of Water discharged.
Feet.	Inch Square.	Min.	Sec.	
1	1	9	22	20
2	1	6	40	20
3	1	5	20	20
4	1	4	44	20
5	1	4	14	20
6	½	17	33	20

TABLE V.

Showing the results of BOSSUT's Experiments with pipes of different lengths, and inclined so as to form the hypothenuse of a right-angled triangle;—the hypothenuse being to the altitude, as 2124 to 241.

Head of Water in inches.	Diameter of Pipe in lines.	Length of Pipe in feet.	Cubic inches discharged in a minute
10	16	59	5808
10	16	118	5801
10	16	177	5795

TABLE VI.

Quantities of Water discharged by rectilineal and curvilineal pipes, fifty feet long and one inch diameter, in BOSSUT's Experiments.

Height of Water in the Reservoir.		Form and Position of the Pipes.	Cubic inches of Water discharged in a Minute.
Feet.	Inches.		
0	4	Rectilineal pipe placed horizontally . .	576
1	0	Ditto ditto	1050
0	4	Curvilineal with the Flexures lying horizontally	540
1	0	Ditto ditto	1030
0	4	Ditto with the Flexures placed vertically and a slight inclination .	520
1	0	Ditto ditto ditto	1028

TABLE VII.

The results of Messrs. Smeaton and Brindley's Experiments to ascertain the quantity of Water discharged from a reservoir by rectangular notches.

Width of notches in inches.	Depth in Inches.	Cubic Feet of Water discharged.	Time of each Experiment. Min.	Sec.
6	1	20	7	16
6	$1\frac{3}{8}$	20	4	55
6	$2\frac{5}{16}$	20	2	19
6	$3\frac{1}{4}$	20	1	33
6	$6\frac{1}{2}$	20	0	30
6	5	20	0	46
6	$1\frac{1}{4}$	20	5	26
6	$1\frac{5}{8}$	20	3	55
6	$5\frac{3}{8}$	20	0	42

TABLE VIII.

Showing the results of Du Buat's Experiments to determine the quantity of Water flowing over a weir $18\frac{1}{2}$ English inches in length.

Depth of Channel in English Feet.	Cubic Feet of Water actually discharged.	Estimated quantity by the rule.
1·778	506	524
3·199	1222	1218
4·665	2153	2155
6·753	3750	3771

The rule for the above estimate is,—multiply the square root of the cube of the depth of the upper edge of the wasteboard below the surface of the water by $11\frac{1}{4}$, and then by the length of the wasteboard, which will give the quantity in English inches.

If the quantities in the preceding tables be analysed and compared, a remarkable coincidence will be perceived although there are some differences; and their approximation to uniformity has led to the following conclusions:

1. That in equal portions of time, the quantities of water discharged from a reservoir, by orifices of the same diameters, and with the same head of water, are nearly as the areas of those orifices.

2. That in equal portions of time, the quantities of water discharged from a reservoir, by orifices of the same diameters, but under the pressure of different heads of water, are nearly as the square roots of the corresponding heights of the water in the reservoir, above the centre of the orifices.

3. That in equal portions of time, the quantities of water discharged from a reservoir, by apertures of different diameters, and under different heads of water, are to one another in the compound ratio of the areas of the respective apertures, and the square roots of the heights of water in the reservoir.

The disparity between *theoretical* calculation, and the *real* discharge, according to Bossut's experiments (Table II.) demonstrates the necessity and importance of bestowing much attention to various considerations, in planning water-works for the supply of towns. In long trains of pipes, having different diameters, curvatures, &c. friction and other circumstances, so greatly modify and retard the motion of the water, as very materially to diminish the quantity discharged in a certain portion of time; hence a proportionate increase of their dimensions becomes requisite, to render them completely effective for supplying distant points, in a limited period.

THE END.

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